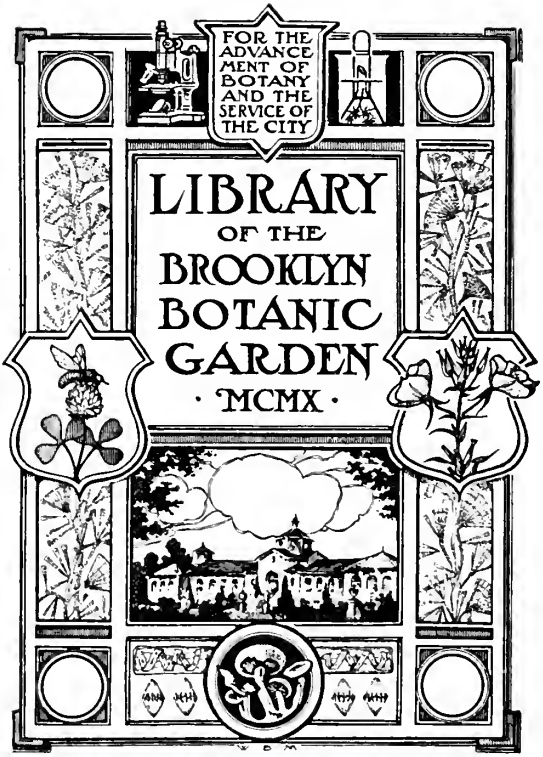

· THE BROOKLYN INSTITUTE OF ARTS & SCIENCES ·

BROOKLYN BOTANIC GARDEN

LEAFLETS

SERIES 1 BROOKLYN, N. Y., APRIL 10, 1913 NUMBER 1

FOREWORD

The purpose of the Brooklyn Botanic Garden *Leaflets* is two-fold: first, to give announcements concerning flowering, and other plant activities, to be seen in the Garden at the time the leaflet is issued; second, to give popular, elementary information about plant life, primarily for teachers, or for others who may wish to learn something about plants besides merely their names. Thus, some of the numbers will aim to give, in simple non-technical language, the subject matter for a nature study lesson, which may be conducted by a teacher, in the Garden or elsewhere.

One copy of each number will be distributed free to teachers, and, on application, to members of their classes in local schools, both private and public, and to members of the Department of Botany of The Brooklyn Institute of Arts and Sciences. It is hoped that the *Leaflets* will thus serve to keep the Garden in touch with its active constituency, and will give timely and helpful information to those teachers who may wish to avail themselves of the opportunities offered at the Garden in connection with their work. Until further notice the period of issue will be irregular. The numbers issued in one calendar year constitute a series.

C. S. G.

SOME PLANTS FLOWERING EARLY IN APRIL

In the native wild flower section of the Garden there are only a few of the native American plants that bloom in early April. These are shrubs and trees bearing inconspicuous flowers in catkins, in the case of the willows, alders, and birches; and more showy flowers on some of the shrubs.

Among the alders, which are just north of the bog, there are two species, *Alnus incana*, which is the more common alder along our northern water courses, and *A. rugosa*, which is more common on the coastal plain than inland. Both of these produce rather inconspicuous catkins very early in April, or sometimes in March. Often they become tree-like, but usually they are shrubby.

Among the willows, *Salix lucida*, as yet too small to flower, *S. discolor*, *S. sericea* and *S. tristis* are all to be found near the bog. The first three will ultimately become very large shrubs, but *S. tristis* (the sage-willow) is a dwarf plant, rarely exceeding one and a half feet. Unlike most willows, it grows naturally in dry soil, and its ashy, grey-colored stems make effective landscape material in masses.

The shrubs with more attractive colored flowers, blooming in April, include the spice-bush (*Benzoin aestivale*), now covered by a mass of yellow flowers, which appear some time before the leaves unfold. In the bog, and with tiny, white, cup-shaped flowers, is the leather leaf (*Chamaedaphne calyculata*), with a natural range from the Arctic tundra to the warm bogs of Georgia. It thrives most successfully in bogs, but can be grown also on dry hillsides, if the soil conditions are suitable. The leatherwood (*Dirca palustris*), a plant with a somewhat similar common name, but inhabiting uplands, is found in the shrubbery planting along the Flatbush Avenue side of the local flora valley. It has light yellow flowers, and is, perhaps, more brittle than any other native shrub.

The herbs flowering in April include, among others the bloodroot (*Sanguinaria canadensis*), which sends up numerous white

flowers, followed later by the coarsely-veined, heart-shaped leaves. The dried root-stocks, collected after the leaves wither in the summer, are much used in medicine. The bloodroot is growing, with many other American woodland plants, by the shaded path, along the crest of the Flatbush Avenue border mound. Both kinds of hepatica (liverleaf) are now flowering, *Hepatica triloba* apparently grading imperceptibly into *H. acuta*. In fact it is impossible, by regarding leaf-characters alone, to distinguish these two closely related forms. A series of leaves from both species may be so arranged as to show a gradual transition from the form characteristic of one species to that characteristic of the other. Both species are in a bed on the western side of the local flora valley.

The Shepherd's-purse, or "pickpocket" (*Capsella Bursa-pastoris*), with white flowers, is common throughout the grounds. It has become naturalized from Europe, and flowers continuously from early April to late August. The plant varies so widely in the characters of its leaves and flowers that one botanist claims to have identified over sixty distinct forms or elementary species.

Of the shrubs not native in America one of the earliest flowering is the "cornelian cherry" (*Cornus mas*) from Japan. Its yellow clusters of flowers cover the whole plant weeks before the leaves appear. It is often nearly tree-like. Most of these shrubs are to be found along the Flatbush Avenue border screen. The Tartarian honeysuckle (*Lonicera tatarica*) with yellowish-white honeysuckle-like flowers, is also in bloom early in April. This interesting Asiatic shrub is the ancestor of more than thirty horticultural forms, many of them of great beauty and utility in landscape effects. Another yellow-flowered shrub, scarcely two and one-half feet high, is the Spanish broom (*Cytisus scoparius*) noteworthy for its profusion of bloom or otherwise naked branches. It is becoming naturalized in the Eastern States, and wherever thoroughly established makes a unique combination in the American landscape. There is a large group of the Scotch broom at the north end of the native wild flower garden.

N. T.

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BROOKLYN BOTANIC GARDEN

LEAFLETS

SERIES 1 BROOKLYN, N. Y., APRIL 16, 1913 NUMBER 2

THE OPENING OF BUDS

The opening of buds and the return of song birds herald the approach of spring, and much of interest may now be seen in the Garden in connection with both of these events. Though we encourage the birds, we are primarily interested in the buds.

A bud is really a branch in the making—an embryo branch, and is one of the many devices by which plants are enabled to pass the winter in safety. This statement will surprise some readers, for many people do not understand that the so-called "spring buds" are always formed during the preceding summer and autumn.

A branch is a lateral portion of the stem of a plant, usually bearing some kind of leaves. During the spring the axis of the branch elongates and may also increase in diameter. The foliage leaves expand their blades, extend their stalks, and become turgid and green. They adjust their positions with reference to each other so as to secure the most favorable illumination, and under the influence of the sunlight they manufacture food for the entire plant.

But if we examine the branches of a tree (such as the horse-chestnut), or a shrub (such as the lilac), during the latter part

of autumn, we shall find that the leaves toward the tip of the branch are frequently smaller than those below them, and that the distance between the places of leaf attachment near the tip has become shorter.

At the very tip the stem has practically ceased to elongate, and a very great change has taken place in the shape of the leaves and the way they grow. In place of the large, beautiful foliage leaves of the horsechestnut, for example, we shall find stiff, brown scales, covered with a sticky substance, and closing in together. These scales, and the newly formed parts of the stems which they enclose, together constitute a bud.

Why it is that scales appear instead of foliage leaves is one of the many mysteries of plants. No one really understands this. How it is that the scales fold together seems, at first thought, also difficult to understand, since plants have no muscles with which to move their parts. It is, however, easier to explain this, at least in part. It is because the modified leaf, or bud-scale, does not grow equally fast on opposite sides. The under (or outer) side elongates more rapidly than the upper (or inner) side, and this is why the scales close in together. But what it is that causes the under side of the bud-scale to grow faster than the upper side we do not understand. There are many theories about the matter, but the fact is that no one at present really knows. Finally, by the time the bud is made and the foliage leaves have fallen off, winter comes on, and practically all growth and all food-making cease. Buds are formed, not only at the tips of the main stem and its branches, but also in the axil of every foliage-leaf.

How is it that the bud protects its tender parts during winter? Inside the bud-scales many buds, and notably those of the horsechestnut, have a quantity of wool-like material closely packed in around the embryonic leaves. It has many times been stated, even in books on nature study and botany, that the bud-scales and the woolly substance protect the tender parts from freezing. It is very easy, however, to demonstrate that this is not correct, for if anyone will cut into any bud on a winter's day when the thermometer is below the freezing point, he will find much ice

inside, and the bud may be frozen solid. Although it seems a pity to have our minds disabused of the poetic fancy of the young "baby twig" tucked away, snug and warm, from the cold of winter, we can easily see that such is not the right interpretation of a bud.

The bud coverings may be of advantage in protecting the bud from too sudden changes of temperature, but what the bud-scales, and the sticky substance, and the woolly material really do is to prevent excessive loss of water from the young leaves and stem. On the colder days of winter, when these parts freeze, some of the water leaves the tissues and forms ice crystals on their surface. Were it not for the protection of the bud coverings, this water, on thawing out, would evaporate into the air faster than it could be reabsorbed into the plant. The parts would then wilt, and several repetitions of this during the winter would be sure to kill the living parts. They would die, not from cold, but from excessive loss of water.

This actually happens sometimes when an unseasonably warm period in early spring is followed by freezing weather. The warm weather causes the buds to partly open, and this exposes the tender parts within, so that when the cold spell follows, they are not protected against the loss of water caused by freezing and subsequent thawing.

But when the warmth of spring returns, the buds begin to open. This they do by processes precisely opposite to those by which they were formed during the preceding autumn.

In the heart of the bud the stem portion begins to elongate, and the embryonic leaves begin to expand. The lower and outermost scales are usually dead, but some of the inner scales, and especially their lower portions, have remained alive all winter. These scales begin to grow again, but now the upper (inner) surface grows faster than the lower (outer) surface, and the scales, in consequence, bend outward. By their growth, and also by the expansion of the inner parts, the external, dead scales are pushed outward, and thus the bud gradually opens.

Under the genial influence of the heat and light of the sun the leaves soon begin to turn green, but at first they droop,

hanging quite limp on the branch. After a few days, however, water begins to enter the leaf-blade faster than it is lost by evaporation, and the blade becomes turgid, *i. e.*, expanded to its fullest extent. It is then able to manufacture food, not only for itself, but for the other parts of the tree, all through the growing season. Some of this food goes to nourish the next set of buds, which are being formed during the summer and autumn in preparation for the following winter.

C. S. G.

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BROOKLYN BOTANIC GARDEN

LEAFLETS

SERIES 1 BROOKLYN, N. Y., APRIL 22, 1913 NUMBER 3

KINDS AND POSITIONS OF BUDS

By the time this copy of the *Leaflets* reaches its readers the opening of buds will be well advanced, and may be seen to advantage in the Botanic Garden, or, indeed, wherever plants are growing.

A bud is often called the "promise of a branch." The shrubs and trees are now displaying their buds very conspicuously. In the case of such herbs as golden-rods, Mayapple, dahlias, and others, although the parts above ground are dead during the winter, the buds are formed on roots and underground stems, well protected just under the surface of the ground, waiting for the warmth of spring to start them into activity. Even seeds possess inside a tiny bud of growing leaves and stem, called the plumule, at the tip of the little axis. Tulip and hyacinth bulbs, and other bulbs, "onions", and heads of cabbage are, in reality, only different kinds of buds

We also have actively growing, summer buds, as well as dormant, sleeping, winter buds. In the case of many greenhouse plants and those of moist tropics, the buds grow actively throughout the year, whereas, in colder climates, like ours, or even in those parts of the tropics where seasons of drought alternate with rainy seasons, the buds must undergo a period of rest. We can easily see that active buds need no special protection; but those which rest over winter, or through a dry season, need to be protected by scales, or in some other way.

When we open buds and examine their inner structure, or, better still, watch them opening of themselves in the spring, we find that some contain only small foliage leaves, others nothing but flowers, still others both leaves and flowers. We call these different kinds *leaf-buds*, *flower-buds* (or fruit buds) and *mixed-buds*. Buds which contain leaves only are very common, and may be found on shrubs and trees, as well as on many other plants. Buds containing flowers only, are to be found very commonly on early spring-flowering plants, such as the alder, cottonwood, and dogwood, or on fruit trees, such as the apple, peach, and cherry. Mixed buds, however, as will be seen on the horse-chestnut, maple, lilac, apple, and pear, or, in fact, on most late spring-flowering plants, are thicker and stouter than others.

Besides studying the internal structure of buds, it is interesting to note their varying positions, especially those of shrubs and trees. One of the first things which strike the attention is the regularity of occurrence of buds. It is true that after cutting off some tree trunks, such, for example, as a willow, *adventitious* buds (so called because they are borne irregularly), spring from the top, or almost anywhere along the stem, or even the roots. But the regular place of occurrence is either on the ends of the branches, when they are called *terminal* buds, or on the sides of the branches, when they are called *lateral*, or auxiliary, buds. The latter term comes from the fact that these lateral buds are borne above the leaf, in the "axil" (armpit), or angle formed by the leaf-stalk and the stem on which it is borne. If we look in the axils of leaves during the late summer or fall, we shall find the buds quite readily; frequently only one, sometimes several in each axil. One looks for them in vain, however, in the plane tree, sycamore, or in the locust, or the honey-locust, while the leaves are still on, for the buds of these trees are covered up and protected by the bases of the leaf-stalks. The sycamore has an especially interesting arrangement, for the base of the leaf-stalk is hollow, and covers the conical bud until autumn, like a tiny candle extinguisher. In the locust, the buds are very rudimentary, and are found best during the winter or spring underneath the corky bark which covers the leaf-scar formed when the leaf falls.

As stated above, buds occur regularly in the axils of leaves; therefore, the buds are arranged like the leaves. When the leaves fall off in the autumn, the buds are more clearly seen, just at or above the scars left by the leaves. Some plants, like the lilac, have their buds in pairs, opposite each other; more often they occur singly in a spiral arrangement around the stem.

When the little shoots push out from the winter buds in spring time, the bud-scales, now no longer needed, fall off. Just as in

the case of the fallen leaves, a scar is left wherever a bud-scale was attached. Look carefully and these scale-scars will be seen to occur on many trees and shrubs in little groups at intervals around the stem. At the base of each year's growth, these scars are often quite conspicuous, forming a sort of ring. So definite are their rings, in fact, that the succession of them on a branch serves to mark very clearly the amount of annual growth. During some years the branch grows vigorously, and the rings are then quite far apart; during other years, for some reason, as from drought, or from too much shade, or from injury, growth is retarded, and the rings are then closed together. Often these annual additions to the growth of the main stem (of a young pine, for example) are so clearly marked that the succession of bud-scars may even serve for calculating the approximate age of the tree.

E. W. O.

SOME NATIVE WILD FLOWERS NOW IN BLOOM

Among the plants to be seen flowering in the local flora section this week are the goldthread (*Coptis trifolia*). There is a good-sized patch of this interesting herb along the shaded walk on the Flatbush Avenue border mound. The name is well taken, as the mass of rootstalks suggest a network of golden threads spreading through the soil. Another interesting plant, the wild ginger (*Asarum canadense*) is just putting forth its peculiar, brownish-purple flowers. Near it is a group of the only common broad-leaved sedge of our region (*Carex Fraseri*), which is now covered by clusters of its golden-green flowers. One of the wake-robins (*Trillium erectum*), with its dark, purple-brown flowers, is also blooming. Though an inhabitant of rich woods from Maine to North Carolina, this plant is very rare on Long Island, being for the most part confined to the north shore. It increases in frequency and profusion of bloom as one goes northward in the Hudson Valley.

The shrubs in this section of the Garden that may be seen in flower now include the low, prostrate currant (*Ribes prostratum*), sometimes called the skunk currant. It is the only one of the native group of gooseberries and currants that creeps over the ground instead of having the conventional upright habit. It may be used with good effect in covering north-facing slopes

and banks, as its natural home is in the far north, and among rocks and on banks. The native shrub having, perhaps, the most fragrant foliage and twigs is the sweet-fern (*Myrica asplenifolia*), just now covered with its clusters of golden-brown catkins. The dwarf yew (*Taxus canadensis*), the only native representative of the yew family, which is little more than a low, straggling evergreen bush at best, is also now bearing its inconspicuous flowers on the under side of its slender twigs.

South of the large gate, on the western, or Flatbush Avenue, side of the Garden, are two trees of *Pyrus grandiflora* just coming into bloom. This tree, however, does not belong to the local flora.

N. T.

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BROOKLYN BOTANIC GARDEN

LEAFLETS

SERIES 1 BROOKLYN, N. Y., APRIL 30, 1913 NUMBER 4

SOME PLANTS FLOWERING EARLY IN MAY

The unusually mild winter and early spring have been the means of hurrying the appearance of many spring flowering plants.

In the native wild flower garden, along the top of the west border mound, one of the rarest of American native herbs is the golden seal (*Hydrastis canadensis*). As in the case of the ginseng, the plant has been widely exploited as a financially productive medicinal plant. But, unlike the properties of the ginseng, the hydrastine which is extracted from the yellow rootstock is certainly medicinally valuable. Its single, whitish-green flower is not showy, and the economic possibilities of the plant account for its wide cultivation. It requires shade and woodland soil.

Near it on the path, and bearing white flowers, is the toothwort (*Dentaria diphylla*), one of the few native plants of the mustard family that grows in the woods. Belonging to the saxifrage family are two herbs that are usually covered with flowers at this time, the false miterwort (*Tiarella cordifolia*), and the bishop's cap (*Mitella diphylla*) both of our rich woodlands, and both more common northward than elsewhere. Either of them makes an attractive plant for naturalizing under trees and among rocks.

In the bog, the plants of the large marsh marigold (*Caltha palustris*) are just about to pass from the flowering to the fruiting stage. This plant is quite commonly used in the Eastern States for "greens", under the name "cowslip". Just south of the bog is a gently rising bank with most of our native violets, planted in patches in the grass. Of these the Canada violet (*Viola canadensis*) and the Labrador violet (*V. conspersa*), both with bluish or violet flowers, are blooming; and the yellow flowered *Viola pubescens* is also nearly ready to bloom.

In the beds containing the rose family are to be seen the white flowers of the wild strawberry (*Fragaria*), and the yellow flowers of the cinquefoil (*Potentilla canadensis*), hardly distinguishable when in the flowerless condition, except by the fact that the strawberry is three-leaved and the cinquefoil is apparently five-leaved (actually three-leaved).

Near these beds is the borage family, containing the beautiful Virginian cowslip, or bluebells (*Mertensia virginica*), with large clusters of showy, light blue, tubular flowers. It is the only representative of the genus growing within the local flora range,* and is rather rare hereabouts, specimens being known from near Tuxedo and adjacent New Jersey, but not from Long Island. This plant should not be confused with the common cowslip (*Caltha palustris*) mentioned above. The cowslip of the English poets is also a very different plant (*Primula veris*), not usually found in American gardens.

Among the native shrubs, the least conspicuous of those considered in this LEAFLET is the wild black currant (*Ribes floridum*), with its spiny stalks and the small clusters of yellow-white flowers. This is the wild American representative of the common cultivated black currant, which is derived from *Ribes nigrum*, an European plant, not as yet cultivated in the Botanic Garden.

Much more conspicuous, but of color offensive to many, is the redbud (*Cercis canadensis*), on the East side of the local flora valley. The innumerable magenta flowers of this shrub, borne as they are on the naked branches, make the Judas-tree, as it is often called, a very conspicuous feature of the landscape in certain

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* The local flora range, from any part of which plants may be collected for the wild flower section of the Garden, is as follows: All of the State of Connecticut; in New York the counties bordering the Hudson River up to and including Columbia and Greene, also Sullivan and Delaware counties, and all of Long Island; all of New Jersey; and in Pennsylvania, Pike, Wayne, Monroe, Lackawanna, Luzerne, Northampton, Lehigh, Carbon, Berks, Bucks, Schuylkill, Montgomery, Philadelphia, Delaware and Chester counties. This territory lies roughly within a radius of one hundred miles from the Garden.

parts of the country. It is one of a small group of typically southern plants that reach their northerly coastal outpost in the southern Delaware valley in New Jersey and adjacent Pennsylvania. Illustrating well the relationship of our native flora with that of Japan is *Cercis japonica*, almost an exact counterpart of our own redbud. It will be found in the shrubbery planting along the north side of the local flora valley, facing the reservoir. Like our native species, it makes blazes of color in any landscape of which it is a part. Both species are perfectly hardy on Long Island, and may be grown in ordinary garden soil.

Not many exotic shrubs are flowering this week, but the white flowers of the pearl bush (*Exochorda grandiflora*) are to be seen along the border mound on the Flatbush Avenue side of the Garden. The curious black bony fruits of this Asiatic shrub are still clinging on from last season. Also white flowered, but with opposite instead of alternate leaves, is the white kerria (*Rhodotypos kerrioides*) from Japan. While it begins to flower at this season, it is quite likely to continue blooming at intervals all summer. Another method of distinguishing these two white flowering shrubs from each other is that the flowers of the pearl bush have five petals while those of kerria have four.

On the east side of the bog and facing toward it in the local flora valley, there is a collection of twenty-one varieties of the lilac, all derived from the common lilac (*Syringa vulgaris*). This well known favorite is, of course, not an American plant, but native in central Europe, where as a wild plant, it is by no means so common as the abundance of its numberless horticultural forms would suggest. In fact, the wild ancestor of our cultivated lilacs is a rare plant of which the Botanic Garden has secured a specimen from the banks of the Danube, collected by a correspondent of the Arnold Aboretum. This plant is still in the nursery, and not yet ready for installation in the collections. Of the different forms of the lilac, some are white, some pink and various shades of lavender; some double, but most of them single. It is unfortunate that the Latin name of the lilac, *Syringa*, is the popular name of a very different shrub, *Philadelphus*, with large white flowers. This unfortunate condition arose as a result of the deliberate mixing of these names by Linnaeus. Before his time, Syringa was the Latin name of what is now *Philadelphus*, and it is only natural that the name still clings to *Philadelphus* as a popular name, and that Syringa is applied to the lilac only as a technical name by botanists. The lilac belongs to the olive family, while the syringa (*Philadelphus*) belongs to the hydrangea family.

Along the Flatbush Avenue border mound, near some grading work now in progress, are several trees of what are perhaps the showiest plants in the Garden. These are the flowering crab apple (*Pyrus floribunda*), from Japan. When mature it is either a large shrub, or, as in our specimens, a small tree, covered at this season with a profusion of deep rose-red flowers. In some of the most beautiful private estates in America, this splendid plant has been used with magnificent effect, as it is more conspicuous than any of our native wild crab apples and their relatives. There are semi-double flowered forms in cultivation, but not at the Garden. Through an error, this tree was inadvertently referred to as *Pyrus grandiflora* in the last LEAFLET.

N. T.

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BROOKLYN BOTANIC GARDEN

LEAFLETS

SERIES 1 BROOKLYN, N. Y., MAY 7, 1913 NUMBER 5

THE POLLINATION OF PINES

The making of a seed is a wonderful process, as indeed are all the life processes of plants. With some plants the process occupies a few days only, with others a few weeks, while some plants require over a year to complete the work. Among the latter class are the pines.

It is a matter of common knowledge that all seeds contain an embryo plant, and the so-called "germination" of a seed is essentially the resumption of growth of this embryo, after a longer or shorter period of rest.

As is the case with animals, all plants are developed from eggs, or (in some of the lower plants) from the equivalent of eggs; but these eggs, as is also the case with animals, must, with a few exceptions, first be activated or fertilized by fusion with a sperm.

The egg is formed in the pistil or carpel of the flower; the sperm in a portion of the stamen. In some kinds of plants, such as the elm, lily and violet, both egg and sperm are borne by the same flower; but in other kinds, such as the poplar, hop, and willow, the egg and sperm are borne on separate individuals. In still other plants (Indian corn, castor-bean, begonia, and others) both eggs and sperms are borne on the same plant, but by different flowers—the eggs by pistillate flowers, the sperms by staminate flowers.

To the latter kind belong the pines, the commonly known (carpellate) pine cone bearing the eggs, which gradually develop into embryos. The sperms are formed within the pollen grains, which are produced in a second kind of cones, the staminate cones. The staminate cones are not as commonly known as the seed-bearing cones, but at this season of the year, and usually in May in this climate, the staminate cones mature and shed their pollen.

In the case of the pines, the pollen, which resembles a fine yellow dust, is carried to the egg-producing cones by the wind. Each tiny grain of pollen has two little air-sacs, or balloons, which make it very buoyant in the air.

When the staminate cones are mature, only a very gentle motion serves to shake out the pollen, which is then borne on the breeze to the egg-bearing cones, where it finally lodges in such a position that the sperms within may finally reach the egg, and fertilize it. The depositing of the pollen on the proper part of the egg-bearing cone is *pollination*.

In the climate of New York the pollination of pines usually takes place about the middle of May, but this is an unusually early spring, and the shedding of pine pollen is now in progress, and may be observed in several places in the Garden, or in Prospect Park, across the street.

If one gently shakes a limb of a pine tree bearing mature staminate cones, the pollen will be shaken out in large quantities, and will float away through the air as a fine cloud. The writer once exposed a photographic negative in front of a tree which had just been vigorously shaken, and the mass of pollen that resulted made the negative look as if it were "fogged." In the photographic print the pollen cloud showed very distinctly.

Of course this method of pollination is very wasteful of pollen, for most of the grains do not lodge in the proper place to accomplish pollination. On this account, vast quantities of pollen must be produced, and during the season of pollination the air is laden with pollen grains. The writer once found a thin deposit of pine pollen inside a closed drawer, in a botanical laboratory. The drawer had not been opened during the period of the shedding of the pollen, but the windows of the laboratory had been open, and the pollen had been wafted in through the windows from nearby pine trees, and carried by the wind into every crack and crevice.

The following paragraph from *The First Book of Farming*, by Goodrich, illustrates the great abundance of pollen shed by wind-pollinated (*anemophyllous*) plants, and also emphasizes what a very wasteful process this is:

"You have sometimes noticed in the spring that after a rain the pools of water are surrounded by a ring of yellow powder, and you have perhaps thought it was sulphur. It was not sulphur, but was composed of millions of pollen grains from flowers. One spring Sunday I laid my hat on the seat in church. When I picked it up at the end of the service, I found considerable dust on it. I brushed the dust off, but on reaching home I found some remaining, and noticed that it was yellow, so I examined it with a magnifying glass and found that it was nearly all pollen grains. Then I rubbed my fingers across a shelf in my room and found it slightly dusty; the magnifying glass showed me that this dust was half pollen. This shows what a great amount of pollen is produced and discharged into the air, and it shows that very few pistils could escape even if they were under cover of a building."

In this connection it is of interest to recall the fact that the so-called "monsoon dust" of the south Atlantic Ocean was at one time thought to be due to large quantities of pollen blown by the wind from the extensive forests of pines and other conifers along the coast of Brazil. It was supposed that the pollen settled on the ocean surface, and gave the peculiar yellowish or yellowish-green color to the water. Careful studies of this "dust" by Reinsch, a few years ago, showed, however, that the "monsoon dust" is in reality due to two or three species of blue-green algae, which accumulate in great quantities at intervals during the year. The phenomenon is sometimes referred to as "sea blossoming."

Residents and travelers in the Adirondack mountains are also familiar with the so-called "water-bloom," or "blooming" of some of the numerous lakes of that region. The guides on the tract of the Adirondack League Club commonly refer to this appearance as the "flowering" or "blossoming" of the lakes. In 1901 samples of water from a "blossoming" lake were collected by Mrs. Annie Morrill Smith, a member of the Department of Botany of the Brooklyn Institute, and given to Dr. M. A. Howe, of the New York Botanical Garden, for determination. It was found that the "flowering" of the lakes is due, as in the case of the monsoon dust, not to floating pollen, but to large quantities of an alga, known in this case as *Rivularia echinulata*.

A similar appearance, frequently observed in the glacial lakes of Minnesota and Wisconsin, has also been found to be due to the presence of an alga. The phenomenon known in Germany as *Wasserbluethe*, and in England, as the "breaking of the meres."

C. S. G.

PLANTS NOW IN BLOOM

In the local flora section of the Garden there are a few shrubs now flowering, among them the two species of chokeberry, *Pyrus arbutifolia* and *Pyrus melanocarpa*. *Pyrus arbutifolia* is much like the other species, except that it has red fruit, but both of them have white flowers. They are attractive, medium-sized bushes, situated on opposite sides of the grass aisle leading from the local flora valley to the Museum building. The red-fruited *Pyrus arbutifolia* is known from Staten Island, but not from Long Island. The other species is common everywhere. Another native shrub, on the east side of the valley is the beach plum (*Prunus maritima*) common all along the coast. It has white flowers followed in the summer by delicious, small, plum-like fruits, with a purple bloom, highly prized in making preserves. The much smaller sand plum (*Prunus pumila*) is near the other species, and is just passing out of flower.

In the bog are two typically northern shrubs, famous for the beauty of their flowers. Rhodora (*Rhododendron canadense*) with beautiful rose-pink flowers, is one of the most attractive shrubs

of the northeast. The habit of flowering before the leaves appear has been beautifully described by Emerson, in his "Rhodora" as "leafless bloom". At the opposite end of the bog are plants of the Labrador Tea (*Ledum groenlandicum*), with shiny russet leaves, and small white flowers. Both these shrubs inhabit the cold bogs of the far north, and are not at all at home here on Long Island; they are found wild in the Catskills. In their native region, they flower usually earlier than this, but these plants have only recently been transplanted.

Along the shaded path, the lady's slipper, or moccasin flower (*Cypripedium acaule*) with its pink blossoms, will be in bloom by the end of the week. It is the only one of the group in which the flower springs directly from the ground, instead of being borne on the leafy stem, as in the yellow-flowered species.

Near the lady's slipper is a cluster of the common wild geranium (*Geranium maculatum*), sometimes called cranesbill. The rootstocks of this purple flowered herb are much used in medicine.

The globeflowers of Europe are so common in gardens that we are surprised to find how rare is the American globeflower (*Trollius laxus*). This buttercup-like plant, with pretty greenish-yellow flowers, is now blooming on the path. It is very rare hereabouts, having been found on Long Island years ago, but not recently. It is more common in Rockland County than elsewhere.

Among plants not native, the horse-chestnut (*Aesculus Hippocastanum*) is about to open its erect cluster of cream-white flowers. Also, the Japanese barberry (*Berberis Thunbergii*), perhaps the most horticulturally satisfactory barberry known, is now flowering. It is common in most of the decorative plantings in the Garden, and may be recognized by its small clusters of tiny white flowers. The red fruits of this shrub remain on all winter, making it useful as a decorative plant when little of this nature is available.

One of the few yellow-flowered shrubs to bloom in the spring is the true kerria (*Kerria japonica*), one of the rose family. It has curious greenish twigs, and a profusion of yellow flowers. There is a fall-flowering strain of this species, which is more common in the nurseries than the spring flowering form. Our plants are about midway of the Garden, along the Flatbush Avenue fence.

N. T.

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BROOKLYN BOTANIC GARDEN

LEAFLETS

SERIES 1 BROOKLYN, N. Y., MAY 14, 1913 NUMBER 6

PLANTS FLOWERING IN THE LAST HALF OF MAY

HERBS

A.—WITH WHITE OR CREAM-COLORED FLOWERS:

Along the shady path, in the local flora section, are two species of baneberry, *Actaea alba* and *A. rubra*, both native American woodland plants, and both used in medicine. In flower the two species are almost indistinguishable, but later on, when the fruits develop, *A. rubra* has red fruit and *A. alba*, as its name indicates, has white fruit. Near it on the path is a group of the mandrake, or May-apple, *Podophyllum peltatum*, with cream-colored flowers half hidden by the large flat leaves. It is used extensively in medicine, being the basis of the well-known mandrake pills. It is a common plant in the Eastern United States, but is unknown as a wild plant on Long Island, and rather rare on Staten Island.

B.—WITH YELLOW OR PURPLE FLOWERS:

Along the border mound, among the orchids, the beautiful yellow-flowered lady's slipper (*Cypripedium parviflorum*) is just about to come into flower, and will be in full bloom on Satur-

day and Sunday. It is not nearly as common as the pink lady's slipper, and, unlike that plant, the flowers are borne on the stem and from among the upper leaves. It is common in the East, but unknown on Long Island or Staten Island.

In the beds of the native crowfoots (*Ranunculaceae*) are several species of buttercup. Many of our commoner plants of this genus are of European origin, among them the field buttercup (*Ranunculus acris*) and the creeping species (*R. repens*) which, in contrast to the erect habit of *acris*, has a low prostrate habit, and usually forms dense mats. In the same beds are plants of the beautiful European columbine (*Aquilegia vulgaris*), with showy, violet-purple flowers, very unlike the rather regular flowers of true buttercups. It will probably continue to flower during most of the spring, and is an excellent garden plant for ordinary situations. Inhabiting woodlands, is our native species (*A. canadensis*), which, however, seems quite at home in the open bed. This plant is often called honeysuckle, but it is preferable to reserve the latter name for the various species of *Lonicera*. The wild columbine is a medicinal plant of some value. In the bed devoted to the poppy family, in the local flora section, is a large clump of celandine (*Chelidonium majus*), a yellow-flowered perennial from Europe, widely naturalized along our roadsides. It has a bright orange-yellow juice, which stains very readily anything with which it comes in contact. This juice, which is especially plentiful in the underground part of the plant, is medicinal, and is used by some as a home remedy for the removal of warts.

SHRUBS AND TREES

Near the plants of the arbor-vitae, on the northeastern side of the lake, are some large plants of the tamarisk, which belongs to the genus *Tamarix*, an Old World group of plants, with almost juniper-like leaves, and showy clusters of pinkish flowers. There are other groups of these feathery shrubs along the Museum side of the local flora shrubbery. Three species are represented in our collections, namely, *T. gallica*, *africana*, and *japonica*, which superficially look alike, and are distinguished by the flower characters, which are rather minute. They make

excellent shrubs for sea-side planting, as they stand the wind and salt air very well indeed.

Among the native shrubs in the local flora valley is the pinkster flower (*Rhododendron nudiflorum*), common throughout the Eastern States, and when full grown, making magnificent color masses in the woods. When mature our specimens will probably reach a height of 8-10 feet. Near the entrance to the valley are plants of the wild black cherry (*Prunus serotina*) and the choke berry (*Prunus virginiana*). They both belong to a section of the cherry genus that has long, finger-shaped clusters of racemose, white flowers, and are often included in the genus *Padus*. They may be readily distinguished by the marginal teeth of the leaves, which in *virginiana* point outward, while in *serotina* they are incurving. The latter, too, is a large tree when mature. The fruits, though bitter, are not poisonous as some writers have stated. The wilted leaves of *Prunus serotina* are, however, poisonous.

Near the source of the brook there are several plants of the English hawthorn (*Crataegus Oxyacantha*), with its many lobed leaves, and fragrant white flowers in profuse clusters. It is commonly cultivated here, and frequently escapes in old gardens and along roadsides. There are many native species of thorns (*Crataegus*) in the the northeastern corner of the local flora valley, but they are as yet too small to flower. Along the shaded path, and, indeed, all along the border screen, are large shrubs of *Lonicera Xylosteum*, the European fly-honeysuckle. It has yellowish or cream-colored flowers, and makes an attractive shrub at this time of the year. It is sometimes found as an escape from cultivation in the east. On the west side of the local flora valley are plants of the strawberry-bush (*Euonymus americanus*), a low, green-twigged shrub, situated about half way down the valley. It derives its name from its red, showy fruits, which are alleged by some to resemble a strawberry. The flowers, which are now covering the bush, are small and greenish-yellow, and not in the least showy.

While most of the roses flower in June or later, there is one species *Rosa rugosa* from Japan, which is just ready to flower.

It is a very prickly, rough-leaved shrub, often reaching six feet in height, and the brilliant green of its leaves is splendidly contrasted by the large, deep-rose flowers, which start blooming at this season, and often continue until September. It will grow in any good garden soil, and is one of the hardiest and most satisfactory of wild roses to grow. There are several colonies of this rose on the Museum side of the local flora shrubbery. Near there are also several plants of the genus *Abelia*, with pinkish white flowers. This is a low bush, scarcely more than two feet in height, and is covered with a profusion of bloom.

Near the newly developing economic section, just south of the local flora valley, are shrubs of the silvery-leaved *Elaeagnus multiflorus*. Its yellow flowers, with long tubes and short petals, are not very showy, but the plant is interesting because of the hairs on all parts of it, and also for the brownish dots on the flowers, twigs, and under side of the leaves. It is a native of Japan, and makes good-sized bushes, averaging ten feet in height.

N. T.

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BROOKLYN BOTANIC GARDEN

LEAFLETS

SERIES 1 BROOKLYN, N. Y., MAY 21, 1913 NUMBER 7

THE LEAVES OF PINES AND OTHER CONIFERS

The young, pale-green shoots of the pines and other evergreen trees growing around the lake, toward the east side of the Garden, have been lately shooting forth at a prodigious rate. They point straight up, away from gravity; and only later turn down to assume the usual oblique or horizontal position of the branches. An examination of these young shoots reveals the presence of the little groups of needle-shaped leaves, as well as the two kinds of cones referred to in Leaflet No. 5. The staminate cones are generally at or near the base of the shoots, and occupy the same relative position as the little spur shoots; the carpellate cones are found near the tip of the shoot. The leaves of the pine, when pulled off from the shoot, are seen to occur on short branches called "spur shoots", in groups of twos, threes, or fives, according to the species; and, further, each spur shoot is wrapped up in one or more protecting scales, and subtended by another scale borne directly on the main axis.

As will be seen from this description, there are really three kinds of leaves borne on these trees (1) spore-bearing leaves (sporophylls), consisting of carpels (making up the carpellate, or seed-bearing, cones), and stamens (making up the staminate, or male, cones); (2) foliage leaves (green, and generally needle-shaped, or flattened, or scale-like); and (3) scale leaves (some covering the winter buds, others wrapping up the young spur shoots or subtending these shoots). There are no floral leaves, (sepals and petals) such as occur in the higher flowering plants, so that the term flower, as commonly understood, cannot properly be applied to the carpellate or staminate cones.

The pines and related trees, such as spruce, firs, hemlocks, and cedars, are often called "evergreen" trees. Two of the group, however, the larch (*Larix*) and the bald cypress (*Taxodium*) of

the South, shed their leaves every fall, like other common deciduous trees. Even the so-called "evergreen" trees do not retain their leaves throughout life, but shed them after some years, varying from three or four in the pine to ten or twelve in the spruce. The question as to the length of time the old leaves hang on the trees makes a very interesting one for study. It can usually be answered quite readily by noting on the twigs the successive scars of the old bud-scales, the portion of the stem between any two successive rings of bud-scale scars, of course, constituting one year's growth.

The needle-shaped leaves of the pines and spruces, and the flat, scale-like leaves of the arbor vitae and white cedar are not often associated by the majority of people with the broad leaves of the common hard-wood trees. Yet they are true foliage leaves, and do the same work as other foliage leaves. Their stiff, rigid shape and their general structure show that they are admirably adapted to resist very trying climatic conditions, such as drought and severe cold. For this reason, the conifers are the most successful trees of the the cold north and of mountain tops.

Another interesting fact to which attention may be called is that the leaves of pines and other conifers, on young or "juvenile" plants, are very different from those on mature specimens. In the case of pine seedlings, for example, the leaves produced the first year, and for several years thereafter, are borne singly, arising directly from the main stem instead of in little groups from short, lateral spur shoots, as they are in later stages. These so-called primary, or juvenile, leaves of the pine, arising directly from the main axis, are really of the same structural value as (i. e. homologous to) the scales spoken of above, which subtend the spur shoots. While ordinarily, in older stages of the red cedar and arbor vitae, very small, awl-shaped leaves are found, appressed close to the stem, still one often finds juvenile forms of these same species, on which occurs an entirely different sort of leaf, needle-shaped, and spreading away from the stem. Thus we find illustrated among plants a phenomenon quite similar to that among men, indicated by the expressions, "an old young man," and "a young old man," the juvenile forms of these trees corresponding to the latter.

Some search will, in fact, often reveal juvenile forms of leaves even on certain branches of quite old plants. Some of our Garden junipers, on the north shore of the lake, near the outlet, and other conifers show this phenomenon very clearly.

The following key, based entirely on leaf characters, may be used for identification of the more common representatives of the genera of conifers found growing in the Botanic Garden, and in the parks and lawns about Brooklyn.

E. W. O.

BRIEF KEY TO THE MORE COMMON GENERA OF CONIFERS FOUND GROWING IN THE BROOKLYN BOTANIC GARDEN AND VICINITY, BASED ON LEAF CHARACTERS.

A. LEAVES EVERGREEN.

1. *Leaves secondary* (*borne on spur shoots*).
   - a. Leaves borne on short spur shoots in 2s–6s, 1 to 15 inches long - - - - - - **Pine** (*Pinus*).
   - b. Leaves linear, 1 to 3 inches long, borne on branchlets in large, alternate clusters - - - - - - **Cedar of Lebanon** (*Cedrus*).
   - c. Leaves in whorls of 20–30 to each branchlet, 2–4 inches long - - **Umbrella Pine** (*Sciadopitys*).

2. *Leaves primary* (*borne directly on the main axis*).
   - a. Leaves ½ to 1 inch long, many ranked, 4-sided - - **Spruce** (*Picea*).
   - b. Leaves 1½ to 3 inches long, many ranked or often 2-ranked, flat, with blunt tip, fastened to the cylindrical stem by a disc-like base - **Fir** (*Abies*).
   - c. Leaves short petioled, linear, ½ inch long, obtuse, dark-green above and white beneath, appearing 2-ranked - - - - - - **Hemlock** (*Tsuga*).
   - d. Leaves strong-scented, small, scale-like or awl-shaped, closely appressed and overlapping - - **White Cedar, or Ground Cypress** (*Chamaecyparis*).
   - e. Leaves needle-shaped, rigid, in whorls of three, ½ inch long - **Common Juniper** (*Juniperus communis*).
   - f. Leaves very small, awl-shaped, appressed, dark-green - - **Red Cedar** (*Juniperus virginiana*).
   - g. Leaves of two sorts; one awl-shaped, the other scale-like and appressed, making a fan-like spray - - **Arbor Vitae** (*Thuja*).
   - h. Leaves needle-shaped, $\frac{1}{6}$ of an inch or less long, sharp-pointed, scattered spirally around the branches, mostly appressed - - - - - - **Mammoth Tree** (*Sequoia gigantea*)
   - i. Leaves ½ to ¾ inch long, roundish, smooth, 2-ranked, flat - **California Red-wood** (*Sequoia sempervirens*)
   - k. Leaves 1 to 2 inches long, awl-shaped, rigid, closely overlapping, completely covering the thick stems in whorls of 6 to 8 - - - - - - - - **Norfolk (or Chile) Pine** (*Araucaria*)

l. Leaves ½ inch long, 4-angled, curved and tapering - **Japanese Cedar** (*Cryptomeria*).

m. Leaves flat, linear, rigid, dark-green, generally 2-ranked, about ¾ inch long - - **Yew** (*Taxus*).

n. Leaves flat, linear, apparently 2-ranked, about 1 inch long - - - - - - - **Torreya** (*Tumion*).

o. Leaves variable in shape and attachment, linear or oblong, with a single median nerve, or with parallel veins - - - - - - - - *Podocarpus.*

B. LEAVES DECIDUOUS.

a. Leaves secondary, more than 6 to a spur shoot - - **Larch** (*Larix*)

b. Leaves primary, flat, linear, ½–¾ inch long, appearing in two rows on the slender branchlets - - **Bald Cypress** (*Taxodium*)

c. Leaves on secondary shoots, resembling those of maiden-hair fern - - **Maiden-hair Tree** (*Ginkgo*)

(The Ginkgo is really not one of the conifers, but is closely related to them, and grows very commonly in lawns in our vicinity).

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BROOKLYN BOTANIC GARDEN

LEAFLETS

SERIES 1 BROOKLYN, N. Y., JUNE 4, 1913 NUMBER 8

THE WORK OF GREEN LEAVES

Green leaves are the "laboratories" of the plant. So very important, indeed, is the work of manufacture there carried on that we may even call them the most important chemical laboratories in the world. The stem part of the plant may in some respects be really regarded as only a subordinate structure in comparison with the leaves. Stems have been likened to a sort of clothes-line on which the green tissues are hung, and thus spread out and exposed to the sunlight.

Green leaves are the food-factories of the world. All food comes from this food made in green leaves. All animals are really dependent upon plants for their food; were it not for green plants and sunshine working together, the food supplies of the world would soon be exhausted and animals would starve.

How is this wonderful work done? While we know quite a little about the process, much remains to be found out. Somehow, light acts on the green color (called "chlorophyll"—leaf-green) of leaves and causes them to form this food. Sunlight is of course the best and most stimulating kind of light for the work of green leaves. The light of the full moon, which is only $\frac{1}{600000}$ that of the sun, causes such little results as to be hardly measurable. But strong electric light and gas light cause the food-making process to go on to a certain extent, especially if the light be kept near enough to the plants. In some experiments carried on at Cornell University some years ago, on the effect of such artificial light, it was found that some plants, as lettuce, could be made to form food successfully by electric

light at night, as well as by daylight. Lettuce thus "forced" was made ready for the market a couple of weeks earlier than the crop which had daylight alone. Quite a number of plants experimented with were, however, seen to be injured by the arc light. Probably this was due to the rays of ultra-violet light or else to particles thrown off from the naked arc light, since the plants did not seem to be so much injured if the arc was surrounded by a ground glass globe. But enough was found out in these experiments to justify the conclusion that there is no need for plants to rest at night, like animals; they can be made to work at the process of food-making by night as well as by day without apparent injury.

The green leaves are thin and spread out so as to catch and absorb all the sunlight possible. They will absorb on a bright, warm, summer day as much as 40–70 per cent. of this light; or when the light is very dim and diffused, as in the depths of a forest, as much as 95 per cent. Of this absorbed light, only a very small amount is really used in the process of food-making; probably not more than an amount varying from 0.5 to 3 per cent.

The sunlight, then, is the energy which starts and keeps going the machinery of this complex chemical laboratory. What happens sounds very simple when we learn that the carbon dioxide of the air is being taken into the green leaf and there united with water to make a sugar-like substance, or, as others state it, starch. It is really a very complicated process, however, and probably takes place in a manner comparable to a sort of staircase, the successive steps becoming more and more complicated as we go up. We think that the steps as they go up probably include formic acid, formaldehyde, glucose (grape sugar) and finally starch. At any rate, the changes, whatever they are, go on very rapidly. If we put a green plant in the dark for a few days, then test it for the presence of starch in its leaves, we will not find any. Then if we bring the plant into the sunlight, and again try for starch with an iodin solution, we now find the leaf turning blue in an incredibly short time, showing that a few minutes only suffice for starch to be manufactured in considerable quantities in the leaf. This wonderful process of food-formation has been well named. It is called "photosynthesis"—"light building-up". A chemist can imitate a few steps of the

process in the chemical laboratory, but it takes a green leaf, acted on by sunshine, to do the whole of it.

There are other very important processes going on in the leaf laboratories. As long as the light strikes the leaf, the above process goes on; and at the same time, oxygen is thrown off from the green tissues. The taking out of the carbon dioxide as well as the adding to the air this oxygen, by green leaves, helps to purify the air and make it fit for animals to breath. Everyone is familiar with the fact that green water plants are necessary in an aquarium, for the gold fish or other animal life will die if not supplied with plenty of oxygen.

Now, oxygen is given off and carbon dioxide is absorbed by plants only in the daytime. Both day and night, however, they must breathe, or, better, *respire*. That is, all the living cells, of roots, stems and leaves, are constantly taking in oxygen and giving off carbon dioxide, just like animals and, in fact, as all living things must do in order to live. When a person says that plants and animals are just the opposites of each other in these processes, they are really telling only a half-truth. For, all plants carry on respiration, just like animals, all the time, both day and night. Of course plants do not forcibly draw in the air as we do into the lungs, but they would soon die if their pores and moist surfaces were thickly covered with vaseline or some such substance which would prevent them from breathing in oxygen. It is only those plants which are green which, during the daytime only, carry on an extra process possessed by no animal: that of taking in carbon dioxide and giving off oxygen under the influence of light. Mushrooms, which lack the green, have only the animal-like process, and not the extra one.

Other complicated foods than starches and sugars are also formed in the green leaf laboratories. Starch forms a starting point for that important class of food substances called the proteins, the muscle and nerve forming foods. As stated above, we may really regard the food made by green leaves as the starting point of all food, both animal and vegetable.

Green leaves also evaporate water, for the most part through tiny mouth-like openings called stomata. The evaporation from a young, vigorous beech tree has been calculated to average during the summer months nearly 20 gallons of water a day. At this

rate, it would take only two or three trees to evaporate a whole barrel of water a day. On the other hand, the evaporation from cacti and such desert plants is so small as to be very difficult of measuring. We are uncertain as to what advantage this evaporation may be to the plant; but we do know that the water coming up from the roots serves the useful purpose of bringing to the leaves the minerals which they need for helping to make the living substance and other complex chemical compounds there manufactured.

Food manufacture in green plants is a most important process. The farm crops of the United States manufacture every year, by means of sunshine and the green coloring matter in their leaves, food materials worth $3,000,000,000. This seems all the more incredible when we reflect that it takes nearly 50 square yards of green leaf surface to make a pound of starch in a working day of 10 hours.

E. W. O.

PLANTS NOW BLOOMING

Near the southern end of the local flora valley and at the northern end of the lake are large masses of the mountain laurel (Kalmia latifolia). Its splendid masses of bloom will be at their finest during the present week. The Latin name of this plant commemorates the fact that this beautiful shrub was first discovered by Peter Kalm, an early traveller in America, who sent the specimens to Linnaeus, who named the plant Kalmia.

N. T.

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BROOKLYN BOTANIC GARDEN

LEAFLETS

SERIES 1 BROOKLYN, N. Y., JUNE 18, 1913 NUMBER 9

RESPIRATION IN PLANTS

In the minds of most people, respiration means the same as "breathing". Breathing is generally associated with the forcible intake and expiration of air by the lungs. Respiration should be thought of rather as a sort of triple process: the taking of oxygen to the living cells; the uniting of this oxygen with some of the foods or else with the living substance itself present in the cells; and, finally, the throwing off of carbon dioxide. While some details of the process are still in dispute, this view is perhaps the one generally held.

Now, of course, plants do not have lungs; so that they cannot breathe in the sense of muscular work of lungs. But, for that matter, neither can many of the lower animals; for such animals, comprising such as the insects, worms, jelly-fish, etc., do not have lungs any more than plants. Insects, for example, have, instead, tiny tubes opening on the surface of the abdomen and other parts of the body, which by means of their profusely branching system, carry air to all the internal parts of the body. Even the frog, as every boy knows, does most of its breathing through its moist skin. If its skin becomes dry through having to remain too long in the dry air of a school room, for example, the animal will die, largely through lack of oxygen. Many animals which live in water use gills to supply their blood with oxygen.

Although it is true that plants do not have lungs to pump air into their bodies, they nevertheless have a very efficient system for taking in air and for its distribution. A connected network of canals and air spaces goes from the leaves throughout the

plant, reaching into every part: into the tips of the roots as well as up into the leaves and throughout the stem; so that practically every living cell of the plant is bathed on one or more sides by air from a tiny air space.

These air canals in all land plants and even in all such water plants as the water lily, with floating leaves, open into the outer air by means of tiny mouth-like openings, called stomata, found on all green parts of stems and leaves. The two lip-cells, or guard-cells, of each stoma keep opening and shutting as they become drier or as they take up more water again. In the water lily, the stomata mouths are on the upper sides only of the floating leaves; and the air they take in passes through large air tubes, plainly visible to the naked eye, which lead down the stem and into the roots. Even water plants which are completely submersed in water, such as the pond-weeds, possess comparatively huge canals in their stems and leaf-stalks for circulating their oxygen and other internal gases.

While this system of irregularly branching air tubes and canals in plants may seem very simple compared with the complex system for supplying air to the tissues in higher animals, it is nevertheless a very efficient system, for an adequate supply of fresh air seems to be rarely lacking for plants; except perhaps in such situations as where a land plant like corn, *e.g.*, is drowned out with water. Such plants as alfalfa and corn cannot stand "wet feet" because the extra water about their roots prevents them from getting sufficient fresh air; so that they become literally smothered for lack of sufficient air.

An elaborate circulatory system such as is seen in higher animals is thus seen to be unnecessary for carrying fresh air to the tissues in plants; as the stomata and the system of air tubes connected with them adequately perform this duty. In the higher animals, the blood vascular system has a double function: to carry food as well as air. In plants, in addition to the air canals and air spaces, there is a sort of system of tubes for carrying the sap and food materials, but it is so simple that it can hardly be compared with the blood-carrying system of animals.

Fresh air, then, is as necessary for plants as it is for animals. Respiration, in its essential features: the taking in of

oxygen, the union of the oxygen with the materials in the cells, and the throwing off of carbon dioxide, is really exactly the same process in plants and animals. This fact cannot be too strongly emphasized when we remember that so many people think that respiration in green plants is just the opposite of respiration in animals. This wrong conception comes from confusing with respiration that wonderful process of food-making (photosynthesis) carried on by green plants in the sunshine. No animal, unless it be green with chlorophyll, can perform this process. It is true that respiration and photosynthesis are the opposites of each other, as is shown in the following comparison:

Photosynthesis (in green plants only).	Respiration (in all plants and animals).
1. Goes on in light only.	1. Goes on all the time, both day and night.
2. Water and carbon dioxide are united to make starch (or at least some carbohydrate).	2. Water and carbon dioxide are thrown off.
3. Oxygen is thrown off.	3. Oxygen is taken in and used up in the process.
4. Food is formed.	4. Food is used up.
5. Energy is stored up.	5. Energy is released, and shows as heat and in the work of the living cells.

The process of respiration (aerobic respiration), as described above, takes place when free oxygen is supplied in plenty. In deep-lying tissues of the animal body, as well as in some plants, when the oxygen supply is cut off, a different sort of respiration (called anaerobic respiration) goes on. The oxygen already combined may be actually torn away from the tissues and used up in the process. Some bacteria, for example, as those causing lockjaw and infantile paralysis, are naturally anaerobic, *i. e.*, they can live only when the supply of free oxygen is cut off.

E. W. O.

SHRUBS NOW IN BLOOM

In the local flora valley, hardly any of our native shrubs are now in flower; but the shrubby cinquefoil (*Potentilla fruticosa*), with its yellow flowers, is blooming. It is the only shrubby species of the genus, so far as the eastern species are concerned,

and is native northward. It has been found wild on Long Island. The common elderberry (*Sambucus canadensis*), famed as the source of elderberry wine, is now covered with large showy clusters of small flowers. It is almost "weedy" along our roadsides.

In the shrubbery planting north of the valley and facing the museum building, there are many species of *Deutzia* and *Spiraea* now in bloom, some of which make very attractive garden plants. Among the spiraeas, one of the best is the crimson flowered *Spiraea Bumalda*, "Anthony Waterer," a splendid, usually low bush that will continue flowering most of the summer. The ordinary Bumalda with pink flowers is also found in the shrubbery planting, usually in small masses. Both these forms are easily cultivated, and make the most satisfactory of garden shrubs for the small place. N. T.

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A docent will meet parties by appointment and conduct them through the Garden. Telephone, 6173 Prospect. Mail address, Brooklyn Botanic Garden, Brooklyn, N. Y.

PRECEDING LEAFLETS OF SERIES 1.

1. Foreword. Some plants flowering early in April. (Supplied only with complete sets.)
2. The opening of buds.
3. Kinds and positions of buds. Some native wild flowers now in bloom.
4. Some plants flowering early in May.
5. The pollination of pines. Plants now in bloom.
6. Plants flowering in the last half of May.
7. The leaves of pines and other conifers.
8. The work of green leaves. Plants now blooming.

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The next number of LEAFLETS (Series 1, Number 10) will be issued September 10, 1913.

BROOKLYN BOTANIC GARDEN

LEAFLETS

SERIES 1 BROOKLYN, N. Y., SEPTEMBER 10, 1913 NUMBER 10

SOME INTERESTING VARIETIES OF CORN GROWING IN THE GARDEN

In the ecological section of the Garden, as well as in the plant breeding plots near the laboratory building, the visitor will find some specimens of proterogynous maize (Indian Corn), a race of this much varying plant which matures its silks before its tassel, thus insuring to a greater degree than is commonly the case, the occurrence of cross-fertilization.

Cross-fertilized corn is generally asserted to be preferable to that which is inbred. Why? This brings up the old question of the merits and demerits of inbreeding and cross-breeding. In Indian corn, as is well known, continuous inbreeding tends to produce a preponderance of plants lacking in normal vigor, a fact which has led many people to suppose that this practice directly causes degeneration. In the light of modern research a different explanation has been given for the occurrence of scrubby plants and the loss of vigor in inbred corn strains.

In order to make this explanation clear, it will be necessary to contrast methods of fertilization in corn with some plant such as the pea, in which inbreeding is the rule. A field of corn may consist of many types or varieties, even though planted from the ears of a single plant; while a field of peas or beans, if grown from the seed of one plant, will ordinarily be monotonous in its lack of diversity. Corn is naturally a cross-fertilized plant; hence most corn plants have two separate parents. Peas and

beans, on the other hand, generally practice self-fertilization, each plant having only one parent. The flowers of corn are generally imperfect, *i. e.*, the male (staminate) and female (pistillate) are not borne in the same flower. The former are produced at the apex of the plant in the tassel, while the latter occur on the ear. Each little immature grain of corn has a long "silk" attached to its outer face, the two structures together constituting the pistil of a single female flower. When the silk has extruded itself from the husk for some distance, a fine dust (pollen) from the tassel falls upon it (pollination) and fertilization follows, the end result being a corn grain, containing an embryo corn plant. The details of the process are much more complicated than may be inferred from this brief description. Peas and beans, in contrast to corn, have perfect flowers, *i. e.*, the male and female structures occur together, and in such a position in reference to each other that the pistil is usually dusted with pollen from its own flower. This eventually brings about self-fertilization.

In comparing these two methods of fertilization, the important point to be noted is the opportunity a corn plant has for inheriting characteristics from two different parents rather than from only one, as in the pea. In this we have the explanation of the difference between the fields of corn and of peas. In the one field, through cross-fertilization, many new types of plants may be produced, while in the other, all the plants will have the characters of their one parent. Contrasting the two fields from the standpoint of vigor, one cannot appreciate the fact that the inbred pea is less robust that the cross-bred corn. Yet when two diverse strains of peas are crossed, their first generation progeny show a marked increase in vigor, in comparison with which an ordinary variety of pea would appear to be degenerate.

Through artificial self-fertilization, pure strains of maize have been isolated, some of which produce remarkably well even after many generations of inbreeding. Other strains isolated from the same stock yield only "nubbins"; while still others are very rich in the production of sterile plants, some of which barely retain enough vitality to mature (Fig. 3). After a pure race has been isolated, the degenerative tendency ceases, and the strain

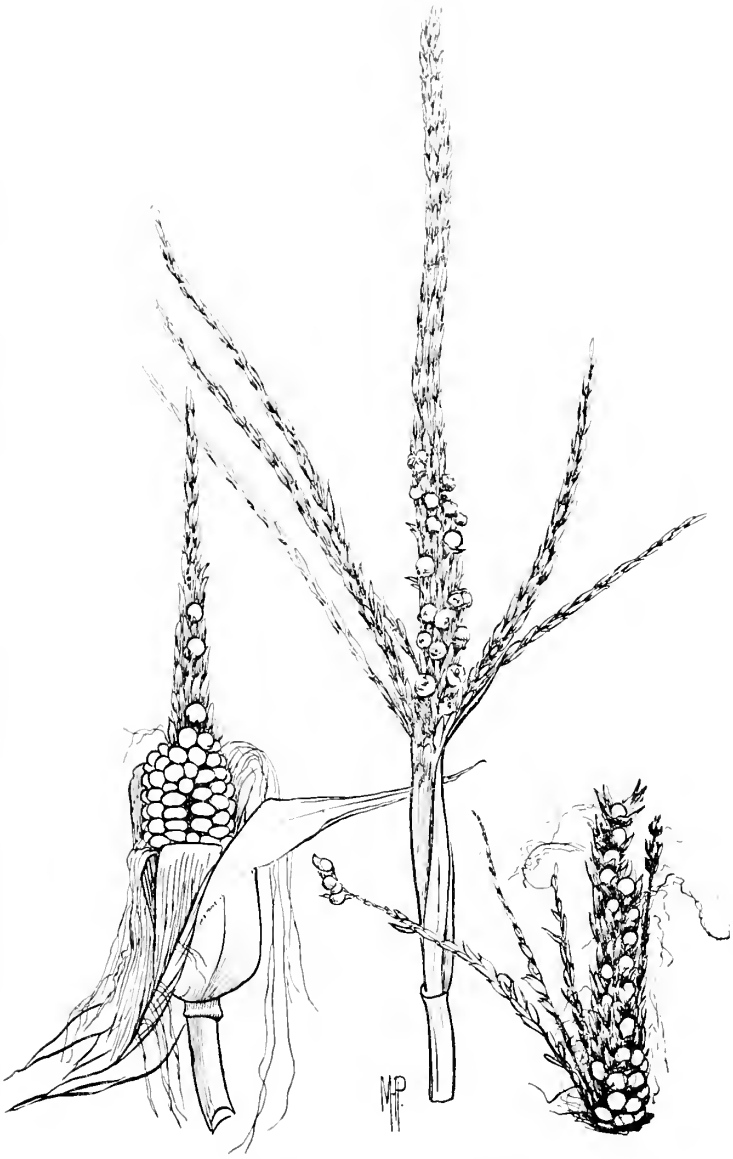

Fig. 1. Ear of sweet corn (female inflorescence) bearing staminate flowers on the end; and tassel (male inflorescence) bearing grains.

then becomes comparable to the varieties of inbred peas and beans, in that its continued self-fertilization will give seed which will produce only plants similar to itself and of equal vigor. But increased vigor and productiveness always occur, just as in the case of the pea, when two of these inbred maize strains are crossed. Inbreeding may be said to result in isolating many pure strains or types, some vigorous, some weak, but none of which are degenerates directly caused by this method of reproduction.

The increased productiveness is strikingly shown in the photograph of Leaming maize (Fig. 4), loaned by the Connecticut Agricultural Experiment Station. On each side are the parents, the center being occupied by a typical sample ear of the first (F_1) generation progeny. A still better idea of the increased productiveness of first generation hybrid corn over the parent strains may be gained from Bulletin No. 243, Bureau of Plant Industry (plates IV and V, pp. 19-26). In the work on which this bulletin was based, two strains of maize were isolated by inbreeding, one of which produced in a given year 47.7 bushels per acre, the other yielding only 16.6 bushels. The crossed seed from these two parents produced 117.5 bushels per acre. Of course, this difference in productiveness between the parent generations and their first filial hybrid generation is not always so marked, but generally the increase is great enough to make the method very important commercially. In practice, the parent varieties are planted in alternate rows and the tassels are completely removed from one variety. The ears of hybrid corn occur only on the detasseled rows, and these, when planted, give the large yields. In order to insure the continuance of this great productiveness, new crossed seed must be obtained in this manner each year, as the second (F_2) generation does not yield so well. As the corn crop in the United States in 1909 was valued at $1,720,000,000, heading the list of agricultural crops in money value, one can readily see the great commercial importance of such a method of increasing yield.

Most corn is either proterandrous or synacmic. In the first case, the tassels mature before the silks; while in the second, the tassels and silks mature simultaneously. A field of proteran-

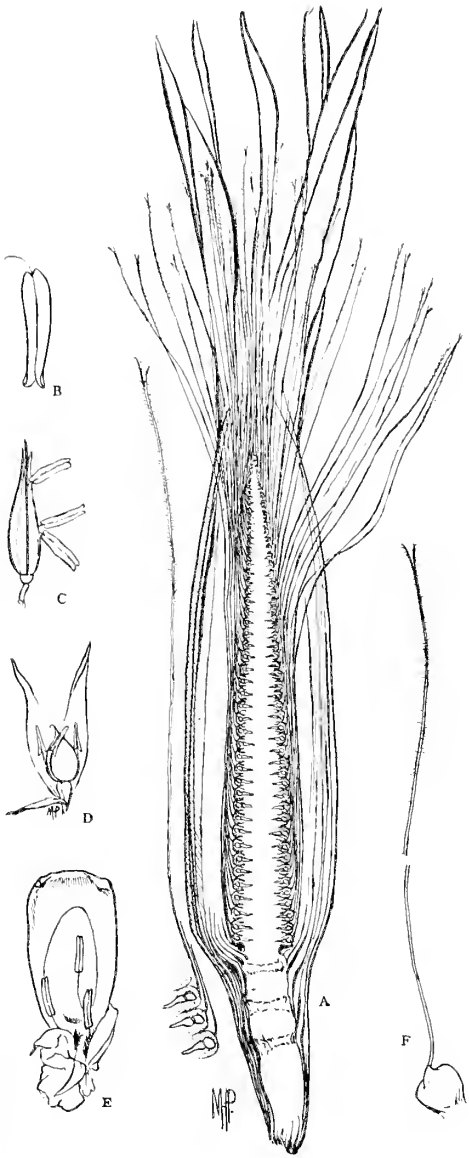

Fig. 2. Reproductive structures of maize.

A. Longitudinal section of ear of corn, showing attachment of silks to immature grains, surrounded by external protective sheaths (husks).

B. Stamen.

C. Male (staminate) flower.

D. Perfect flower from tassel of pod corn.

E. Mature grain, developed from a perfect flower, as shown by the three dried stamens (after E. M. East).

F. Female (pistillate) flower.

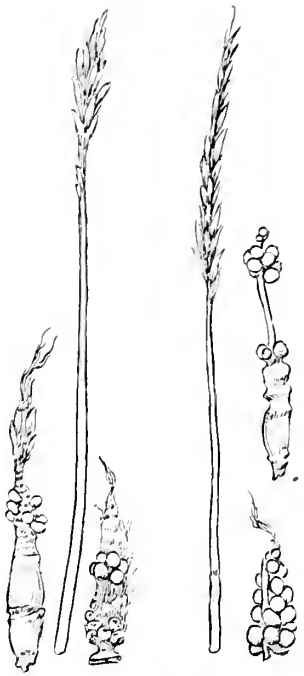

Fig. 3. Tassels and ears from nearly sterile maize plants isolated from inbred strains (after E. M. East).

drous corn would yield largely hybrid seed—each little corn embryo having two parents; while in a field of synacmic corn, a large proportion of the plants would be self-pollinated, unless there were strong winds. According to some authorities, a large part of the cultivated corn of the United States belongs to this latter type; and as seed corn is generally selected on the basis of looks rather than of ancestry, the synacmic character tends to decrease the yield. The introduction of proterogynous and proterandrous races will promote more cross-fertilization and thus tend to increase the yield.

The proterogynous corn now growing in the Garden was secured through the kindness of Mr. G. N. Collins, botanist, crop acclimatization and adaptation, Bureau of Plant Industry, U. S. Department of Agriculture. In Circular 107 of this bureau, he gives a detailed account of its characteristics and its probable value as plant-breeding material. Proterogynous varieties of corn are rare, although, as Mr. Collins states, there are reasons for believing that the more remote ancestors of maize, which are said to have had perfect flowers, were proterogynous. The so-called primitive varieties of maize from South and Central America tend to be proterandrous. Perfect flowers are not infrequently found among the male flowers of the tassel and less commonly on the ear. Pod corn, a type in which each grain is enclosed in a separate husk, is generally rich in perfect flowers, and this peculiar variety (also now growing in the Garden) has often been looked upon as the nearest approach to the wild condition, although it itself is probably of comparatively recent origin.

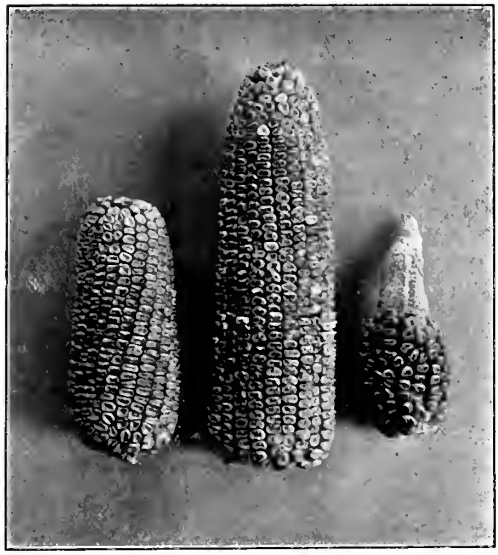

Fig. 4. Showing results of crossing inbred maize strains. Outer ears inbred four generations. Middle ear result of crossing these two strains (after East and Hayes).

Of perhaps even greater interest, on account of its ornamental character, is the "Rainbow Corn," a few hills of which will be found at one end of the Garden nursery. This is an improved strain of the old Japanese white and green striped maize. The Garden specimens show four colors, red, white, rose and green, with a considerable degree of variation in the amount of each color to a leaf. Those plants with the greatest degree of red and white coloration are not as robust as those with more green in their leaves. The cause of this is the inability of the more highly colored plants to produce food as rapidly as those which are provided with plenty of leaf green. This strain of maize faithfully reproduces the striped character in all its offspring.

O. W.

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BROOKLYN BOTANIC GARDEN

LEAFLETS

THE BROOKLYN INSTITUTE OF ARTS AND SCIENCES

SERIES 1 BROOKLYN, N. Y., SEPTEMBER 24, 1913 NUMBER 11

OUR NATIVE SHRUBS AND WHAT MAY BE DONE WITH THEM*

In how many of our gardens can one find any attempt to grow the wild shrubs of the countryside? The scramble for something new, something startling, has almost overshadowed the quieter beauties, the softer harmonies of the shrubs that grow close at home.

The accompanying table has been made up from an actual planting list used at the Brooklyn Botanic Garden of the Brooklyn Institute in the installation of the shrub collections of the wild flower Garden.

It will be noted that under each month group the names are arranged in botanical sequence so that allied plants are brought together. All the ninety-four species are offered for sale in American nurseries. Those in the column "Remarks and Notes" as well as about twenty others not included, must be collected in the wild. Wherever possible the writer will be glad to send information as to the sources of supply.

A word now as to cultivation and care. Most of the shrubs, except those so noted, can either be planted in the spring or fall, as this is a matter that should be determined by the planter's convenience. In digging the holes make them twice as wide and deep as the size of the roots apparently demand. Note carefully the column "Preferred Habitat," so that the shrubs may find congenial surroundings. Pack the soil well around the roots, water thoroughly, and frequently if the weather is dry and windy. The first winter or two a heavy mulch of leaves, or leaves and manure mixed, to be dug in the following spring, will well repay the expense and trouble.

It will be noted that some of the shrubs are marked with a dagger (†). These all belong to the heath family and require

*Reprinted from The Garden Magazine, April, 1912.

special treatment. A soil composed of rotten sods and leafmold, about half and half, is most essential for the successful cultivation of these plants. They require peculiar acid soil conditions well approximated by the above mixture, and a mulch, preferably of red-oak leaves, or the leaves of the mountain laurel if available. Never disturb the roots of these plants by digging in the mulch, which is better left on indefinitely. Soils with much lime in them must also be avoided when growing these heath-family plants.

OTHER WAYS TO USE THE TABLE

It is often somewhat dfficult in arranging a shrubbery planting to group the plants according to the color of their flowers. For the greater ease in using the larger table, and so that one can arrive at the relative frequency of the various colors desirable for use in the scheme, the following table is appended. The nunbers refer, of course, to those in the table below. The figures given in parenthesis is the total of plants in each division.

By color of flowers. Yellow-green (10): 1, 8, 9, 10, 30, 31, 36, 44, 49, 86. Brown-green (10): 2, 3, 4, 11, 12, 13, 14, 15, 27, 39. Yellow (5): 5, 25, 41, 84, 92. Pink-purple (4): 7, 74, 75, 83. White (35): 6, 17, 18, 19, 20, 21, 22, 24, 28, 29, 32, 40, 42, 43, 45, 46, 47, 51, 55, 57, 58, 59, 69, 70, 71, 72, 76, 78, 79, 80, 81, 82, 88, 89, 90. Green-white (11): 16, 23, 33, 50, 52, 63, 64, 65, 66, 87, 94. Pinkish-white (10): 26, 37, 38, 54, 56, 61, 67, 73, 77, 93. Pink (5): 34, 60, 62, 85, 91. Lilac (1): 35. Violet-purple (2): 48, 68. Orange-red (1): 53.

It often happens, too, that we have some definite spot, such as a small stream or swamp, a dry hillside, or a shaded wood, that we wish to beautify. Therefore:

By preferred habitat of shrubs. Moist places (19): 1, 2, 4, 9, 15, 17, 30, 36, 42, 50, 75, 78, 82, 83, 84, 85, 87, 88, 89. Indifferent (32): 3, 5, 6, 7, 12, 14, 24, 29, 32, 35, 37, 38, 41, 43, 45, 47, 48, 51, 52, 59, 60, 61, 62, 68, 70, 71, 72, 79, 80, 81, 90, 91. Shaded woods (13): 8, 16, 23, 25, 26, 27, 31, 63, 65, 67, 69, 74, 92. Dry places (19): 10, 13, 18, 20, 21, 22, 34, 39, 46, 49, 53, 54, 56, 58, 64, 77, 86, 93, 94. Swamps (6): 11, 40, 55, 66, 73, 76. Thickets (1): 19. Cool woods (4): 28, 33, 44, 57.

In planning a screen for an unsightly fence or building, or to cover up some small landscape importunity, it is often essential to know, *en masse*, the heights of shrubs for such purposes. The following table gives the dimensions of the shrubs, normal individuals averaging about midway of the extreme heights given.

By height of shrubs. One to four feet (13): 2, 6, 21, 27, 34, 56, 62, 75, 77, 83, 84, 91, 93. Two to five (24): 10, 11, 13, 16, 22, 25, 31, 36, 37, 42, 44, 53, 57, 60, 61, 65, 67, 69, 73, 81, 82, 85, 90, 94. Three to nine (29): 3, 4, 8, 12, 14, 15, 17, 20, 26, 28, 32, 33, 35, 38, 39, 41, 43, 45, 48, 54, 58, 59, 70, 72, 74, 78, 80, 86, 88. Six to fifteen (21): 1, 5, 7, 18, 19, 29, 40, 46, 47, 49, 50, 52, 55, 64, 68, 71, 76, 79, 87, 89, 92. Ten to eighteen (7): 9, 23, 24, 30, 51, 63, 66.

PLANTING TABLE FOR OUR NATIVE SHRUBS

COMMON AND LATIN NAMES	Height (feet)	COLOR OF FLOWERS	PREFERRED HABITAT	REMARKS AND NOTES
March-April				
1. Pussy willow (Salix discolor)	7-12	Yellow-green	Moist places	Flowers before the leaves come out. *S. cordata*, a larger bush, with broad leaves is worth cultivating. Not in the catalogues.
2. Dwarf willow (Salix tristis)	1-4	Brown-green	Moist places	Useful in masses. Can be made to grow in all sorts of places. One of the very earliest flowering shrubs.
3. Hazel nut (Corylus Americana)	3-6	Brownish-yellow	Indifferent*	Nuts edible and much gathered by the squirrels. The catkins out before the leaves. European hazel nut is a better plant.
4. Alder (Alnus rugosa)	5-9	Brownish-green	Moist places	Will grow in other situations. The fruits, not very strong, will stay on all winter. Useful in masses along brooks.
5. Spice bush (Benzoin odoriferum)	6-15	Yellow	Indifferent	Flowers much before the leaves, very fragrant. Near N. Y. usually not over 10 feet, larger southward.
6. Red chokeberry (Aronia arbutifolia)	2-4	White	Indifferent	Common from N. Y. southward. *A. atropurpurea*, with black fruit is worth while. *A. arbutifolia* has red fruit.
7. Red bud (Cercis Canadensis)	4-15	Pink-purple	Indifferent	Magnificent masses of color before the leaves appear. Sometimes almost a tree. Rare as a wild plant but easily cultivated.
8. Fragrant sumac (Rhus Canadensis aromatica)	3-8	Yellowish green	Rocky woods	Will grow in unlikely places and an excellent shrub for wild effect. Flowers half hidden by compound leaves.
April-May				
9. Shiny willow (Salix lucida)	10-18	Yellow-green	Low places	Will grow almost anywhere. *S. myrtilloides* a shrub 3½ feet, not in the trade, is handsome with yellow catkins.
10. Prairie willow (Salix humilis)	3-6	Yellow-green	Dry places	Will grow almost anywhere. Flowers out much before the leaves. Useful only in mass effects.
11. Sweet gale (Myrica Gale)	3-6	Inconspicuous	Swamps and bogs	Ash colored fruits effective all winter. Will grow in many other situations besides the preferred one.
12. Bayberry (Myrica Carolinensis)	3-8	Not showy	Indifferent	Grows equally well in sand loam, or swampy places. Leaves shining green, long persistent. Fruits whitish; all winter.
13. Sweet fern (Comptonia asplenifolia)	3-5	Golden-brown	Dry hillsides	Golden catkins very showy before the leaves. Whole plant very fragrant. Can be grown almost anywhere.
14. Beaked hazel nut (Corylus rostrata)	3-6	Brown-yellow	Indifferent	Along streams it makes effective screens and borders. The long beak quite distinct from No. 3. Occasionally 8 feet.
15. Hoary elder (Alnus incana)	4-9	Greenish-brown	Moist places	Leaves pale green beneath. With Nos. 3, 4, 14 and 89, it can be used effectively along shores of streams and ponds.

*The term "indifferent" in this connection is used to signify that the plant will adapt itself to average conditions.

PLANTING TABLE FOR OUR NATIVE SHRUBS—*Continued*

COMMON AND LATIN NAMES	Height (feet)	COLOR OF FLOWERS	PREFERRED HABITAT	REMARKS AND NOTES
16. American black currant (Ribes Americana)	3-5	Green-white	Shaded woods	*R. lacustre* and *R. rubrum*, the latter with reddish purple flowers are very fine. Neither in the trade.
17. Juneberry (Amelanchier Botryapium)	5-12	White	Moist places	As individual plants very shapely, but rather ungainly in close formation. *A. spicata* (1-4 ft.) good, but not in the trade.
18. English hawthorn (Crataegus Oxyacantha)	5-15	White	Dry hillsides	The May. Much cultivated and now run wild. The American *C. rotundifolia* common on L. I. and N. J., but not for sale.
19. Scarlet thorn (Crataegus coccinea)	5-15	White	Thickets	The closely related *C. Mollis*, with scarlet fruits is effective in autumn. Not in the catalogues.
20. Dwarf thorn (Crataegus uniflora)	2-8	White	Dry sandy place	Quite indifferent as to locality when cultivated. *C. macracantha* with long spines is often 10 to 15 feet. Not in the trade.
21. Beach plum (Prunus maritima)	1-4	White	Sandy places	Fruit makes excellent jelly. Very successful near the sea. *P. cuneata* better grown near moist rocks.
22. Sand cherry (Prunus pumila)	3-6	White	Dry places	Splendid in masses or small hillocks. Will grow in almost pure sand. *P. Gravessii* not in the trade.
23. Prickly ash (Xanthoxylum Americanum)	6-18	Green	Shaded places	Will also grow in ordinary garden soil. The large compound leaves gives splendid foliage effects.
24. Bladder nut (Staphylea trifolia)	6-20	White	Indifferent	Usually about 10 feet in our latitude. The showy pods stay on most of the winter. Flowers not showy.
25. Leatherwood (Dirca palustris)	2-5	Yellowish	Shaded places	In masses under trees or along shaded walks it is most welcome. Useful in a shaded rockery.
26. Pinkster flower (Azalea nudiflora)	2-7	Pinkish-white	Shaded wood†	A blaze of color when planted in masses with other Azaleas. Can also be grown successfully in the open.
27. Deerberry (Vaccinium stamineum)	1-4	Purple-green	Dry woods†	Flowers not showy, but purple fruits are attractive. Best not disturbed or transplanted after setting out.
28. Red-berried elder (Sambucus pubens)	3-10	White	Cool woods	Easily grown in the garden but most successfully under trees or along the north side of the house.
29. Black haw (Viburnum prunifolium)	5-18	White	Indifferent	After becoming a small tree. A magnificent snowy shrub in the spring. Fruits black.
May				
30. Silky willow (Salix sericea)	6-15	Yellow-green	Moist places	With the other willows useful for filling in low moist places. Leaves ashy beneath. Catkins showy.
31. Wild gooseberry (Ribes Cynosbati)	3-5	Greenish-yellow	Rocky woods	Better grown in the shade and in rich soil. The bristly fruits are odd persistent features of this shrub.
32. Black chokeberry (Aronia nigra)	3-8	White	Indifferent	Shiny black fruit stays on until December or January. Somewhat scraggy, except in masses.

33. Mountain holly (Ilex monticola)	4-10	Greenish-white	Cool shade	Flowers not showy but the red fruits showy all the autumn. Do not attempt to grow in hot, dry places.
34. Blue huckleberry (Vaccinium vaccillans)	1-4	Pink	Dry soil†	The profusion of tiny bell-like flowers appearing with the leaves makes this attractive. Fruits purple-black.
35. Common lilac (Syringa vulgaris)	4-10	Lilac	Ordinary garden soil	Cultivated everywhere and sometimes escaped from gardens. There are scores of attractive hybrids and forms.
36. American fly honeysuckle (Lonicera ciliata)	2-4	Greenish-yellow	Moist woods	Easily grown in ordinary garden soil, but prefers shade. Best planted along shaded walks.
37. Fly honeysuckle (Lonicera Xylosteum)	2-6	Pinkish-white	Indifferent	Sometimes an escape from cultivation. The scarlet berries are showy in the early fall.
38. Tartarian bush honeysuckle (Lonicera Tatarica)	3-8	Pinkish-white	Indifferent	*L. oblongifolia* with purplish-yellow flowers in May and June is attractive. Not in the catalogue.
May-June				
39. Chinquapin (Castanea pumila)	5-8	Brownish-green	Dry soil	Apt to be affected with the chestnut blight. The long catkins and fruit are interesting but not showy.
40. Magnolia (Magnolia glauca)	4-10	White	Swamps and bogs	Can also be grown very well on dry ground and in any garden soil. Fruits rose red.
41. Common barberry (Berberis vulgaris)	3-8	Yellow	Common garden soil	Often an escape from cultivation. The well-known scarlet scarlet berries showy in autumn.
42. Virginian willow (Itea Virginica)	2-4	White	Moist places	When massed either alone or with *Clethra alnifolia* it makes attractive patches of white.
43. Syringa (Philadelphus coronarius)	4-10	Cream-white	Indifferent	Many horticultural forms of this are in the trade. All are useful. Fruits brownish.
44. Fetid currant (Ribes prostratum)	3-6	Greenish-yellow	Cool moist places	Not easily grown as it grows naturally on the cool mountain slopes. Fruits red.
45. Opulaster (Spiraea opulifolia)	3-9	White	Indifferent	Splendid masses of flowers, as it is a profuse bloomer. Often from 3-6 feet wide and very bushy.
46. Cockspur thorn (Crataegus Crus-galli)	6-14	White	Dry soil	One of the most commonly cultivated of our native shrubs. Very thorny and a good hedge plant.
47. Pear haw (Crataegus tomentosa)	4-12	White	Indifferent	The dull red fruits cling on most of the winter. A profusely flowering shrub.
48. Bastard indigo (Amorpha fruticosa)	4-10	Violet-purple	Rich soil	A gorgeous flowering shrub, which in masses is unrivalled. Repays good cultivation and care.
49. Staghorn sumac (Rhus typhina)	6-15	Green	Dry places	Autumnal coloring magnificent. On a low hill very effective in large masses.
50. American holly (Ilex opaca)	6-15	Greenish-white	Moist woods	Best transplanted in the spring, when all the evergreen leaves should be knocked or clipped off.

Plants marked thus (†) belong to the heath family and require special conditions as indicated in text.

COMMON AND LATIN NAMES	Height (feet)	COLOR OF FLOWERS	PREFERRED HABITAT	REMARKS AND NOTES
May-June				
51. Buckthorn (Rhamnus cathartica)	8-16	White	Indiffere	This and No. 52 both European shrubs that have run wild in this country. Neither is showy in flower.
52. Alder buckthorn (Rhamnus Frangula)	4-11	Greenish-white	Indifferent	Its natural home is in swamps and bogs, but generations of garden culture has made it at home.
53. Flame azalea (Azalea calendulacea)	2-7	Orange-yellow red	Dry woods†	The showiest of all our native shrubs. Not very common in the wild state.
54. Mountain laurel (Kalmia latifolia)	4-10	Pinkish-white	Dry woods†	In masses under the shade of trees a wonderfully effective shrub. Prefers rich soil.
55. Swamp huckleberry (Vaccinium corymbosum)	6-15	White	Swamps and wet woods†	Flowers not very showy but the fruits are the finest of the tribe. Will not tolerate dry places.
56. Low blueberry (Vaccinicum Pennsylvanicum)	1-4	Pinkish-white	Dry or sandy soil†	Often grows in almost pure sand in the pine-barrens. Neither flower nor fruit showy.
57. Hobble bush (Viburnum alnifolium)	3-6	White	Cool, moist shade	The outer circle of flowers in each cluster very much larger than the inner. Does not like hot places.
58. Dockmackie (Viburnum acerifolium)	3-8	White	Dry woods	Looks like a small maple tree. Useful as it will grow almost anywhere. Fruits black.
June-July				
59. Hydrangea (Hydrangea arborescens)	4-9	White	Indifferent	Thoroughly hardy and often easier grown than the more showy exotic species.
60. Meadow rose (Rosa Virginiana blanda)	2-4	Pink	Indifferent	Along paths and roadsides it scrambles everywhere with apparent cultural indifference.
61. Sweet briar (Rosa rubiginosa)	3-6	Pinkish-white	Indifferent	Well repays good treatment when it often becomes a bushy shrub 4 to five feet in diameter.
62. Pasture rose (Rosa humilis)	1-3	Pink	Indifferent	The beautiful large petals very evanescent. It can be best grown in a moist place. Showy.
63. Water ash (Ptelea trifoliata)	6-18	Greenish-white	Shade	Flowers inconspicuous but the compound leaves make it a good foliage plant. Wood very brittle.
64. Black sumac (Rhus Copallina)	5-15	Greenish-white	Dry places	The large compound leaves a beautiful scarlet in the autumn. Profuse bloomer and fruits persistent.
65. Inkberry (Ilex glabra)	3-6	Grsenish-white	Moist woods	The more rare *I. mucronata* of swamps is interesting botanically but must be collected from the wild.
66. Winterberry (Ilex verticillata)	6-18	Greenish-white	Swamps	Splendid scarlet fruits cling on in large clusters most of the winter. Often easily grown in the garden.
67. Strawberry bush (Euonymus Americanus)	3-7	Greenish-pink	Low woods	Flowers small and inconspicuous but followed by red fruits that last until December. A slender plant.

68. Burning bush (Euonymus atropurpureus)	8-15	Purple	Indifferent	European shrub much cultivated and now widely established as a wild plant. Fruits red and showy.
69. New Jersey tea (Ceanothus Americanus)	2-6	White	Shade	Effective as massed plantings. The leaves the source of tea in Revolutionary times. A profuse bloomer.
70. Kinnikinik (Cornus Amomum)	3-10	White	Indifferent	Purple twigs effective in winter. The reddish-twigged *C. asperifolia* effective but not on sale.
71. Red osier dogwood (miscalled kinnikinik) (Cornus stolonifera)	3-12	White	Indifferent	Twigs reddish- purple; and fine in masses for its winter color harmonies. Easily grown from cuttings.
72. Cornel (Cornus alternifolia)	3-10	White	Indifferent	The bright green twigs which keep their color all winter make it attractive grouped with Nos. 70 and 71.
73. Swamp honeysuckle (Azalea viscosa)	3-6	Pink and white	Swamps†	Rather shy of dry places but easily replaced in such places by the *A. canescens*, which must be collected.
74. Rhododendron (Rhododendron maximum)	4-18	Rose-white-purple	Woods†	Old plants, almost tree-like, should never be disturbed. Be careful to nip all fruits as soon as they appear.
75. Sheep laurel (Kalmia angustifolia)	1-3	Purple-crimson	Low, moist †places	The rare *K. glauca*, not in the trade, is very much worth while. Neither is happy in open dry places.
76. Leucothoe (Leucothoe racemosa)	5-12	Cream-white	Swamps†	The glossy practically evergreen leaves make an effective winter showing. Can be grouped with Nos. 74, 77 and 78.
77. Staggerbush (Pieris Mariana)	1-4	Pinkish-white	Sandy soil†	Isolated plants are apt to be sprawling, but when massed the delicate flowers make attractive patches of color.
78. Privet andromeda (Xolisma ligustrina)	4-9	White	Moist places†	Leaves partially evergreen, and dark glossy green in color. A profuse bloomer with persistent fruits.
79. Elderberry (Sambucus Canadensis)	5-15	White	Indifferent	In large clusters most effective as a screen. Will grow very well along a stream or pond. Fruits "mussy."
80. Cranberry bush (Viburnum Opulus)	3-12	White	Indifferent	Profuse masses of flowers and large clusters of scarlet berries make it most useful all the year.
81. Withe rod (Viburnum nudum)	2-8	White	Indifferent	The *C. pubescens* of rocky woods equally good but not offered for sale. Fruits blue-black.
82. Appalachian tea (Viburnum cassinoides)	2-8	White	Moist places	*V. Lentago* with black fruits useful, but must be collected. Leaves of *V. cassinoides* glossy and dark green.
July-August				
83. Hard hack (Spiraea tomentosa)	1-4	Pink-purple	Low ground	The ashy underside of the leaves, contrasted with the pinkish-purple flowers is a novel combination.
84. Shrubby cinquefoil (Potentilla fruticosa)	2-4	Yellow	Moist places	One of the yellow flowered shrubs that are used. Sometimes winter kills near New York.

Plants marked thus (†) belong to the heath family and require special conditions as indicated in text.

PLANTING TABLE FOR OUR NATIVE SHRUBS—*Continued*

COMMON AND LATIN NAMES	Height (feet)	COLOR OF FLOWERS	PREFERRED HABITAT	REMARKS AND NOTES
85. Swamp rose (Rosa Carolina)	4-7	Rose-colored	Moist places	Can also be successfully grown in ordinary garden soil, well manured. Flowers soon withering in open sunlight.
86. Smooth sumac (Rhus glabra)	3-12	Greenish	Dry places	Grouped with Nos. 49 and 64, it gives a wild touch to the landscape. Autumn color gorgeous.
87. Hercules's club (Aralia spinosa)	6-15	White	Low ground	Large compound leaves 3 to 4 feet long, make this the foliage plant *par excellence*. Flowers inconspicuous.
88. Sweet pepperbrush (Clethra alnifolia)	3-8	Cream-white	Low ground	Fragrant flowers followed by persistent fruits, a sturdy habit and bushy outline make this a favorite.
89. Button bush (Cephalanthus occidentalis)	5-15	Cream-white	Moist places	Best not attempted much away from water, and in such situations often becoming almost tree-like. Flowers fragrant.
90. Snowberry (Symphoricarpos racemosus)	2-6	White	Indifferent	The flowers are not showy but the conspicuous white berries stay on all winter, thus valuable for winter effect.
91. Coralberry (Symphoricarpos vulgaris)	1-4	Pink	Indifferent	Much like the preceding but the red fruits are not so persistent. Forms a wide spreading bush.
September-December				
92. Witch hazel (Hamamelis Virginiana)	5-15	Yellow	Moist shade	Flowers later than any other native shrub, often after all the leaves have fallen off, and the first frost arrives.
93. Heather (Calluna vulgaris)	1-2	Pinkish-white	Sandy places	Rather shy in its few American localities. Near the coast from Massachusetts to southern New Jersey it should do well.
94. Groundsel tree (Baccharis halimifolia)	2-5	Whitish-green	Dry soil	Best transplanted in the spring as its late flowering makes autumnal activity too great for easy transplanting then.

N. T.

BROOKLYN BOTANIC GARDEN

LEAFLETS

THE BROOKLYN INSTITUTE OF ARTS AND SCIENCES

SERIES 1 BROOKLYN, N. Y., OCTOBER 8, 1913 NUMBER 12

BULB CULTURE

Bulbs are easier to raise in class-rooms and at home and give more pleasure than perhaps anything else in the plant world. Still one must follow certain directions for their potting and culture if success is to be sure.

In the first place, certain kinds of bulbs are easier to raise indoors than other kinds. These should always be chosen in work with young children. The narcissus group is the most satisfactory of all for this work. Choose such members as paper white narcissus, poeticus, Von Sion, jonquils and Chinese lilies. These last are usually the least satisfactory because their blooms blast when exposed to the slightest of draughts.

Hyacinths come next in choice. They fall into two general classes, the Dutch and Roman varieties. The Roman ones bloom earlier than the Dutch. If tulips are chosen, order the early blossoming ones; for on these slower growing varieties, plant lice often develop. Crocuses do well indoors, especially when planted in masses. These, then, are the easiest to raise of all the bulbs for indoor work, and the ones most likely to give success.

Bulbs should be bought during September and October, for all potting ought to be over by the last of October. For this work with bulbs, have ready the bulbs, soil, sand, charcoal, broken crock and the pots.

The Bulbs.—In the first place, order these of any good seedsman. If hyacinths be chosen, remember that the named varieties are more likely to give good results, but they are more expensive than the unnamed ones. If one cannot afford the named varieties, order by color such as the blues, whites, etc. Be sure to choose firm, solid bulbs. These have more strength to do their work; more food supply stored up. For, within the heart of the bulb the flower itself is already formed, ready to push itself up and out into the world, when conditions are right. So the strong bulbs are better fitted for their work than the weaker ones. Remember this, too: that Roman hyacinths bloom earlier than other hyacinths, requiring a shorter resting period. Those planted in October may be had for Christmas bloom.

Soil.—The soil for bulb planting should not be too heavy. Heavy soil clings firmly together when moistened, due to clay in it. Light soil falls apart. If the soil seems to be a heavy one, lighten it with sand, adding about one-third sand to the amount required. Sand not only lightens soil, but it helps by carrying surplus water off. In very heavy soils, water may collect about the base of the bulbs. This causes decay. Free the potting soil from lumps and stones; if it is necessary, sift it.

Pots.—Bulbs may be planted in pots, pans or flats. Pans are low crocks. Flats are low boxes of about four inches in height. The bottom of a flat ought to have holes in it or spaces for drainage. Many bulbs can be planted, just as closely together as possible, in a single flat. When the bulbs are almost ready to bloom they may be transplanted into separate pots. The number of pots to buy depends upon the number of bulbs. It is a matter of calculation. Bulbs need just enough space to grow in, without touching neighboring bulbs. Suppose the pot be a five-inch one: allow two Dutch hyacinths to such a pot; three Roman ones; two

Von Sion daffodils; two paper white narcissus; three poeticus; four jonquils; five tulips, or four if they be large ones; six to eight crocuses, and eight to ten freezias.

Method of Potting.—After all the materials are gathered together, proceed with the potting after this fashion. The hole in the bottom of the pot is for drainage and to allow air to enter

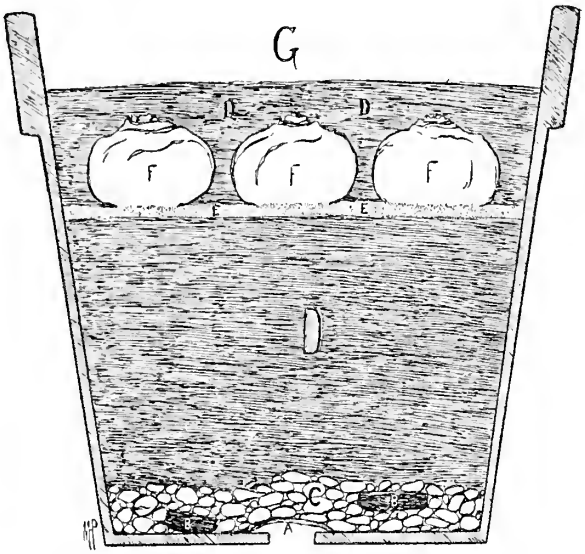

Fig. 5. Longitudinal section of flower pot, showing arrangement of potting materials and bulbs. A, curved piece of crockery over drainage hole; B, charcoal; C, drainage material; D, soil; E, layer of sand; F, hyacinth bulbs; G, space for watering.

and get at the roots. This is important, for roots must have air. To be sure, some air is bound up in the soil, but the roots need more than this. Hence, the hole in the bottom of the pot is for this purpose, and should never be tightly clogged up. Place a curved bit of broken crock over the hole, with concave surface toward the hole. This covering prevents the soil from trickling through, or the water from passing out too fast; but it does not prevent the entrance of air. More air enters than if a straight

piece of crock is placed directly across the hole. After this, put about an inch of drainage material in the pot, but less than this should go in shallow pans and flats. Materials to use for drainage purposes are crock, turf or sod, charcoal or even stone. These are spoken of as drainage material, because a loose area is formed through which water slowly trickles, and at the same time the soil is not clogged with too much water. Charcoal may serve a double purpose, for it is thought by some to sweeten the soil. It is perhaps well to use a piece of charcoal in each pot when other drainage material is not used. One, of course, can raise bulbs successfully without using charcoal at all. The soil goes next after this layer. Now comes another point to calculate, and that is the amount of soil necessary before putting in the bulbs. Find it out thus: Hold the bulb to be used down into the pot so it is in the place it ought to be. Hyacinths should be potted so that their noses (the pointed end of the bulb is called the nose) are one-half inch below the surface of the soil; tulips, one-quarter inch below the surface; and the narcissus group above the soil. The upper surface of soil in a pot should be one inch below the edge of the pot. This space allowed is for watering, so that soil will not flood over the edge of the pot when water is put on. After this, put a little sand over the soil, a layer not more than an eighth of an inch thick. This sand bed acts as a drainage area, allowing water to trickle down and away from the bulb. Now place the bulbs in their sand beds. Leave just space enough between the bulbs so that no two touch. Neither should they touch the sides of the pot. Cover with soil, pressing it down firmly about the bulbs. Now they are ready for the season of rest.

Resting Period.—All potted bulbs should be placed in a dark, cold place for six to ten weeks. Roman hyacinths may be brought in after a month's rest. The object of this resting period is to give time for the roots to develop slowly and surely before the plants are brought into the light. For as soon as this time comes, a bulb expends all its energy in forcing the flowers and leaves so

the work of root making must be done before this time. If the roots are not properly developed, good results cannot be expected. The roots are properly developed when they begin to force their way out of the hole in the bottom of the pot. The pots may be stored for this resting period either indoors or outdoors. If they are to go indoors, select a cold, dark place, such as a cool cellar or basement. The bulbs must be watered once or twice a week. If they are to go outdoors, one of two methods may be employed. Either dig a trench in the ground for them; or prepare a box. If a trench is dug, it must be at least eighteen inches deep, and wide enough to take in the widest receptacles. Place two inches of coal ashes on the bottom of the trench. This layer assists drainage and offers an obstacle in the path of ascending worms. Now the pots of bulbs are placed on the ashes and soil put all about and above them. Fill in the rest of the trench with soil or coal ashes. Coal ashes form a looser layer than that made by soil, so it is easier to shovel off the ashes in cold weather. Never use wood ashes, because of the lye in them, which trickling down to the bulbs would kill them. Leave them thus until you wish to take them in. But allow six weeks for development. Nature does the watering. The second method, that of using a box, is an excellent one for use in schools. Get a box the size you wish; it should have a depth of at least two feet. Put an inch layer of sand, soil or ashes over the entire bottom of the box, placing the pots on this. Cover the pots in the box with sand and then fill the box full with coal ashes. In extreme weather put a covering over the box which is left outdoors, on the ground or a roof. Again nature does the watering. The box may be lined with a heavy wrapping paper, which insures greater warmth. Be sure to mark the pots with wax crayons. This is very essential in school work, so that children may receive their own pots.

Care of Bulbs—When the pots come out of the darkness, do not immediately bring them into direct sunshine. Let this be gradual, first leaving them in a darkened part of a room, and finally when the buds begin to open, see that they receive the direct sunlight.

Water freely, for it helps the blossom to unfold. Never let a pot stand where a draught strikes the plant or the blossoms will blast before unfolding. After the period of bloom is over, let the blossoms, leaves and all completely wither up. Then cut the stalks up to one inch from the bulb itself. Shake all soil from the roots and place the bulbs in the sunshine to dry out. Pack away in tin boxes. These bulbs may be planted outdoors the following fall, but are of little or no value for further work indoors. Chinese lilies can never be used again after one period of blossoming.

Water Culture.—Some bulbs will grow well in water, pebbles and water, or sand and water. Hyacinths do well in tall glasses which the florists and seedsmen sell for this purpose. Fill the glass with water, place the hyacinth in the top of the glass with the pointed end of the bulb up. Now place the glass away in a dark closet, but not necessarily a cold one, until the hyacinth's roots are way down to the bottom of the glass. Then it is time to bring it to the light. Chinese lilies and other members of the narcissus group may be planted in pebbles and water. The pebbles are placed in the bottom of the glass dish or earthern one. Upon this layer, place the bulbs, two to an eight ounce dish, and surround them with pebbles for the purpose of steadying the bulbs. Water should be poured in so that it just touches the base of each bulb. These dishes of bulbs ought to go into a dark closet until good root growth has developed. Paper white narcissus, Von Sions and poeticus may be buried in a bank of sand, but leave the noses of the bulbs sticking out of the sand. Treat these as you would those planted in pebbles and water, except that the entire sand mass must be always saturated with water.

Outdoor Planting.—An outdoor bulb bed is excellent for school grounds, being decorative and easy to plant. Tulips look well in round beds planted in one color masses. Border beds may be filled with daffodils or hyacinths. Crocuses, snowdrops, and little grape hyacinths are planted here and there in the grass.

The single flowered varieties of bulbs are more attractive than the double flowering kinds. In preparing an outdoor bed be sure that the soil is dug up and made fine for a depth of eight inches. Different bulbs are planted at different depths. Hyacinths should go six inches beneath the soil and six inches apart; narcissus and tulips, four inches down and four apart; crocuses, three inches deep and three apart; all small bulbs, like snowdrops, etc., should go only just beneath the surface of the soil. Cover the bulbs over with soil. When the weather becomes cold and just before frost, put about two inches of barnyard dressing (horse manure) over the beds. Later, as the weather grows colder, put a piece of sacking or heavy wrapping-paper over each bed. Hold these down with stones so that the wind does not blow the covers away. This last cover is not an absolute necessity. When the spring comes, take away whatever of the coverings remain and see the tips of the bulbs poking out of the ground. For outdoor planting, buy "bedding" varieties. Do not wait until late October or November to buy bulbs, for they lose value during the fall, shrinking and becoming less strong. The outdoor bulb bed may be left as it is after blossoming time. That is, the bulbs may be left in the ground, and the tops cut off. Of course, all the bulbs could be dug up, dried and planted out again the next fall. These bulb beds should have new bulbs put in about once in four years.

E. E. S.

NOTICES

The Brooklyn Botanic Garden is open free to the public daily, from 8 a. m. until sunset; on Sundays and holidays at 10 a. m.

Entrances on Flatbush Avenue, opposite Prospect Park; on Washington Avenue, south of Eastern Parkway; and on Eastern Parkway, west of the Museum building.

The Entrance to the Laboratory building is on Washington Avenue, opposite Montgomery Street.

The Garden may be reached by Flatbush Avenue trolley to Malbone Street; Franklin Avenue and Lorimer Street trolleys to Washington Avenue; and Brighton Beach elevated to Consumer's Park Station. (Train stops only when conductor is notified in advance.)

A docent will meet parties by appointment and conduct them through the Garden. Telephone, 6173 Prospect. Mail address, Brooklyn Botanic Garden, Brooklyn, N. Y.

Additional copies of this and preceding LEAFLETS may be had on request by mail or otherwise.

BROOKLYN BOTANIC GARDEN

LEAFLETS

THE BROOKLYN INSTITUTE OF ARTS AND SCIENCES

SERIES 1 BROOKLYN, N. Y., OCTOBER 22, 1913 NUMBER 13

KINDS AND CHARACTERISTICS OF BULBS

A bulb is really a bud, more or less fleshy in nature. It is found beneath or upon the ground. This bud shows two general types in its structure: the one kind is made up of fleshy layers, (*tunicated*) like the onion; the other kind is *scaly* and, as the name implies, is composed of comparatively narrow, thick, small scales. At the heart of the bulb the flower and leaf parts are found. The hyacinth and tulip bulbs are examples of the tunicated type; the lily bulb, of the scaly one.

The bulb is so provided for by nature that it is able to live over a long resting period, for every bulb is in reality a storehouse of food. This food, in addition to nutrient matter, contains stored-up energy, which, under proper conditions of water and temperature, enables the bud parts to force their way out. The roots are developed usually from the base, after the bulb is planted, while the leaves and blossoms, which were completely formed by the time the bulb reached maturity in the fall, emerge from the upper part. And it is to be remembered that one never gets more out of a bulb than is already in it at the close of the ripening period. When a bulb is bought, it either has or has not formed the flower. If the flower is not formed, such a bulb will never blossom.

Whenever the term bulb is used, it is understood to refer to flowering bulbous plants in their dormant condition. It is during this stage that bulbs are sent to market and sold. And they should not be kept too long before replanting, for then they wither and lose appreciably in value. Each kind of bulb has its proper planting season and a definite season of bloom. These

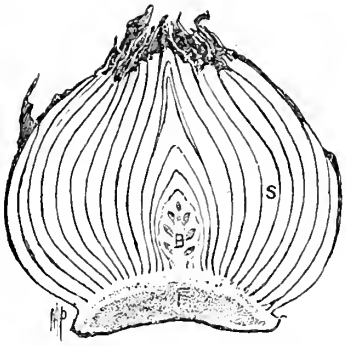

Figure 6. TULIP BULB, longitudinal section. F. Solid stem. B. Flower bud. S. Scale leaf. (Storage leaf).

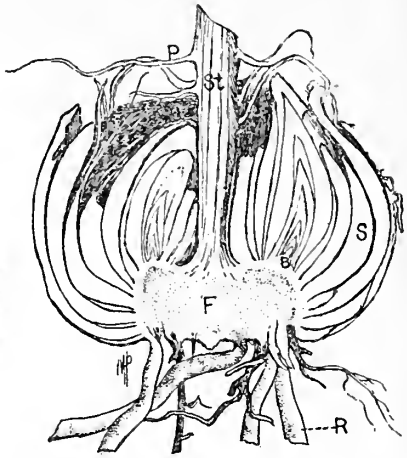

Figure 7. LILY BULB. longitudinal section. F. Solid stem. B. Bud. S. Scale leaf St. Last year's flower and leaf stalk. P. Prop root.

bulbous, flowering plants are very popular, due largely to the fact that they are easy of culture; but somewhat, perhaps, to their comparative certainty of blossoming. There is no other class of plants which has more charming blooms.

During the resting period, most bulbs, after they are planted, are placed in the dark and the cold. The Cape bulbs, however, such as freesia, oxalis and ixia, should not be stored in the dark, but must have a light, cool place in which to start growth. At this time, the nourishment stored in the body of the bulb, should be sufficient to produce good root growth, and later to supply the leaves and blossoms themselves. Because of the great amount of stored food withdrawn from a potted bulb to supply the new growth there is little reserve left after the blossoming period, and so these bulbs, after having been once planted indoors, are of no value for a second indoor planting. This is not true of bulbs planted in the open, for in this case the green leaves are well exposed to an abundance of air and sunlight, and thus, using the energy derived from the sunlight, they are enabled to manufacture a fresh supply of food materials out of the elements supplied by the soil and air. The larger part of these elements, the carbon, is derived from the air.* As fast as this food is made, some of it is used for the immediate needs of the plant, while the remainder passes down into the bulb, where part of it is used in the formation of the new leaves and flowers, and the remainder stored up for the nourishment of these new parts

*The process by which green leaves manufacture food, when properly exposed to sunlight, is described more fully in LEAFLET No. 8, of this series.

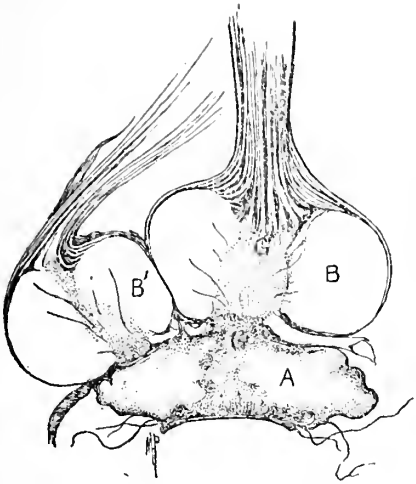

Figure 8. GLADIOLUS CORM, longitudinal section. A. Last year's corm. G. Growing point of last year's corm. B.1 Corms produced this year. G.1 Growing point of the new bulb.

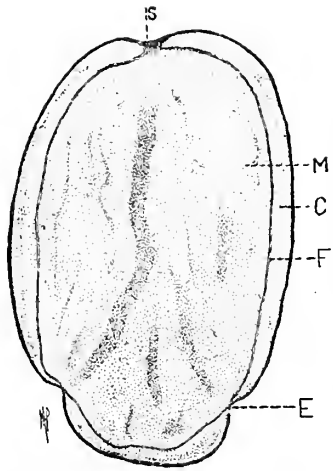

Figure 9. POTATO, longitudinal section. S. Scar of stem attachment. M. Medulla; pulp filled with starch cells. C. Cortex. F. Fibrovascular region. F. Section through eye.

when they resume their growth the following season, after the period of rest. It is for this reason that (as stated in the preceding LEAFLET) bulbous plants should be left in the ground as long as danger from autumn frost will permit, in order that all the nourishment possible may pass into them from the leaves. Nevertheless, outdoor beds should have a few new bulbs put in every four to six years. Thus the beauty of the bed, as a whole, is kept up.

Gardeners often divide bulbs into two classes, according to hardiness. In one class are placed those which withstand the frost; these are the hardy bulbs. In the other class are the tender bulbs, or those which cannot live through frost. In the first class may be mentioned crocuses, snowdrops, anemones, tulips, hyacinths, members of the narcissus family, and iris. In the second class are found dahlias, gloxinias, amaryllis, tuberoses, begonias, caladiums, and others perhaps not so well known.

As will be seen from the above list, the term "bulb" as used by gardeners includes forms which do not strictly, in a true botanic sense, belong in this class, for such botanically distinct structures as corms, tubers, rhizomes, pips and other fleshy roots are included in the term. Now in structure these are not true bulbs.

Corms, are solid underground stems, usually rounded or flattened, and often showing various gradations between bulbs

and tubers (e. g., the crocus). When cut they disclose a solid inner structure, having neither layers nor scales.

Tubers are fleshy portions of underground stems, bearing on the surface, in the axils of much reduced, scale-like leaves, numerous buds, or "eyes", which develop into the new growth. The potato and the dahlia are examples of tubers.

Rhizomes are horizontal or oblique stems, lying on or beneath the surface of the ground, longer than tubers, and usually not so fleshy (e. g., the iris).

The lily-of-the-valley "bulb" is a *pip*; or, strictly, a flowering crown.

Peonies form *fascicled roots*. So we see the term bulb is used in horticulture rather loosely; or rather, comprehensively, for it covers a wide botanic field. All who employ the term should understand this free use of it.

In buying bulbs, it is wise to run no risk, but to buy large, firm ones. These qualities insure at least a good food supply, and a reasonable amount of energy for work. Named varieties are best to buy for indoor potting; while mixed bulbs do well for outdoor bedding. It requires a long period of slow development to produce a good bulb for market. In one case, that of the hyacinth, four to six years are needed to make a good, first class bulb.

E. E. S.

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BROOKLYN BOTANIC GARDEN

LEAFLETS

THE BROOKLYN INSTITUTE OF ARTS AND SCIENCES

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LEAF-FALL

The Fall of the Year. Spring is the season of preparation for life more abundant. Streams that yesterday were held in the icy grasp of winter begin once more to rush in swollen volume, waves again begin to dance and roll on the surfaces of ponds and lakes; migratory birds return to breed and sing; insects burst from dry cocoons and sail away; buds are bursting, seeds are germinating, flowers are blooming, leaves expanding.

Autumn, on the other hand, is a season of preparation for winter. Life in our climate is becoming quiescent; Migratory birds are leaving; insects are spinning cocoons; buds are maturing; flowers are giving place to fruit; seeds are ripening: leaves are falling.

The Fall of the Leaf. The shedding of leaves is one of the most striking and at the same time one of the most wonderful of all plant adjustments to external conditions. In the first place it is wonderful because it anticipates. The external condition that makes it neccessary has not yet been realized; winter has not arrived; and yet the tree makes ample preparation. In the second place, leaf-fall is wonderful because it is a distinct life-process. The leaves are not separated from the tree in a passive way, as dead branches are blown off by the wind; they are actively shed, and in some cases actually pushed off. This is accomplished as follows.

How it is Accomplished. Toward the end of the growing season, a thin layer of cells, frequently of cork, forms at the

extreme base of the leaf, where it joins the branch. The contents of these cells soon die and the result is a region of weakness, so that a slight force, such as a gentle breeze, a flying bird or insect, a falling fruit, or even the weight of the leaf itself, is sufficient to cause it to fall away. In some trees, as for example, the sycamore or plane tree (*Platinus*), the buds form directly in the leaf-base, which fits like a cap over the end. In such a case, a slight enlargement of the bud after the corky layer had formed, would be sufficient to dislodge the leaf. In a similar way, the swelling of buds which grow in the leaf-axil, just above the leaf-base, may rupture the tissue. The corky layer serves as a callus to heal over the wound at once, preventing loss of water and sap, and the entrance of spores or germs which might in time result in injury to the tree. The scars where leaves were attached may be seen on the branches at any season of the year.

Deciduous Trees and Evergreens. All trees shed their leaves sooner or later. In fact, this is one of the several characters by which the botanist distinguishes a leaf from a branch on perennial plants, such as trees and shrubs. Branches (save for accident) usually persist, but leaves are shed sooner or later. In some plants with large, pinnately compound leaves, like the elder (*Sambucus*), the tree of heaven (*Ailanthus*), or the Hercules' Club (*Aralia*), the main axis of the leaf, bearing the leaflets, closely resembles a branch bearing leaves, but its true leaf character is clearly shown, not only by the bud in its axil, but also by it falling away when the leaves fall.

In the case of the five-leaved ivy (*Ampelopsis*) the leaflets of the compound leaf usually separate first from the main leaf-stalk (*petiole*), leaving the latter projecting in a conspicuous manner. Later the leaf-stalks themselves are shed. The compound leaf of the horse-chestnut is also similarly dismembered during leaf-fall.

Not all trees, however, shed all their leaves every year, or all at once. Our own evergreen trees, are indeed evergreen, but not by the persistence of the same foliage. Individual leaves may remain on for as long as three years or more, but one may always see on the ground, under all evergreens, the numerous leaves (needles) that have fallen.

Leaf-fall in the Tropics. In tropical countries the absence of a season like our winter makes unnecessary any periodical shedding of foliage, such as occurs in the temperate zone; nevertheless, the leaves do not persist, but are falling, a few at a time, throughout the year. It is very interesting to see trees in the tropics with a mixed foliage, composed in part of old leaves ready to fall, of new leaves just expanding, and of mature leaves in the full vigor of their activity.

Why Trees Shed Their Leaves. It is very commonly supposed that trees shed their leaves as a protection against cold, that is, to avoid being frozen in winter. This idea, however, is not correct. Winter, so far as the tree is concerned, is not so much a season of cold as a season of drought, and leaves are the principal organs by means of which the tree loses water. During the growing season, water is being absorbed from the soil by the roots, and on the other hand, given off in large quantities from the leaves. When winter arrives, and the ground becomes frozen, the water is changed to ice, and therefore cannot enter the tree. If the leaves remained on, they would continue to give off water, and the tree, not being able to make good the loss, would die.

In pines, hemlocks and other evergreen trees, where the foliage remains on over winter, the leaves have a relatively thick outer skin (epidermis), are covered with a waxy coat, and have their stomata* nearly closed, so that the loss of water is very greatly reduced, if not entirely checked.

In the tropics leaf-fall has no adaptive significance. The leaves remain on until old age renders them of little use to the tree, and then they are shed. The leaves of some palms are not shed in the manner above described, but the leaf-stalk merely breaks off below the blade, leaving the leaf-base, and the lower portion of the stalk attached to the trunk.

Preparation for Leaf-fall. As stated in LEAFLET No 8, of this Series, the chief function of a green leaf is to make food for the plant. Materials taken in from the soil and air are, in the leaf, combined into plant food, which passes down the leaf-stalk to nourish the buds developing in the axils, and the other living parts of the tree. As the season of leaf-fall approaches, this food-making gradually ceases, and most of the manufactured food passes from the leaves into the branches. Thus a bushel of leaves would weigh less (dry weight) at the time of leaf-fall, than the same leaves would have weighed in mid-summer.

In this connection it is interesting to note that the abscission layer, formed at the base of the leaf-stalk, does not at first cut across the strands of vascular tissue (vibro-vascular bundles) through which liquids pass in and out of the leaf from the stem, and thus the passage of the contents of the leaf into the branch is not interferred with.

Autumn Colors. It is a very wide-spread belief that the varied leaf-tints of autumn are caused by frost. Such a belief, however, is based on superficial observation, for beautiful autumn colors may be seen every fall, weeks before the first frost. The exact cause or significance of autumn colors is not well understood by botanists. Some have thought that they were

*Small openings through the epidermis. See LEAFLETS, Series 1, No. 8.

"warming up" colors, serving to protect the leaf against the cooler temperatures of autumn. It seems more probable, however, that these colors are of no special significance in the life of the tree or of the leaf, but are merely the colors of the substances which result when the green coloring matter (chlorophyl) and other contents of the leaves disintegrate, just before the fall of the leaf.

C. S. G.

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